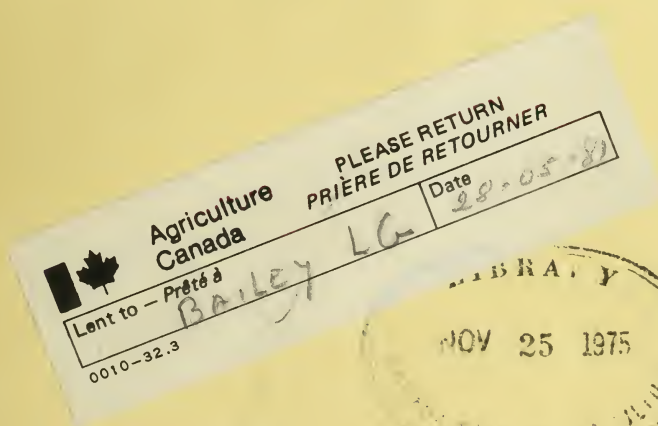


RESEARCH BRANCH REPORT

❧ 1974 ❧



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Research Branch Report

1974

CANADA DEPARTMENT OF AGRICULTURE

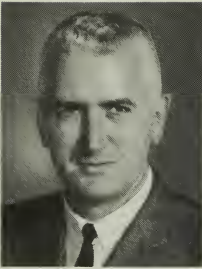
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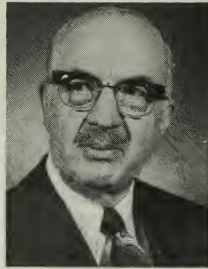
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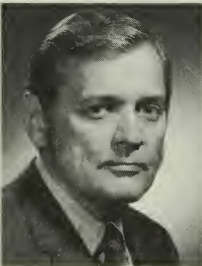
Dr. B.B. Migicovsky



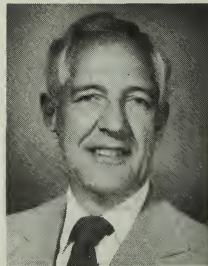
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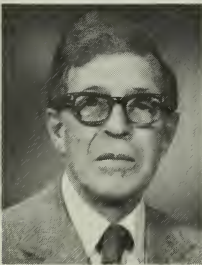
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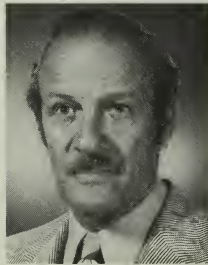
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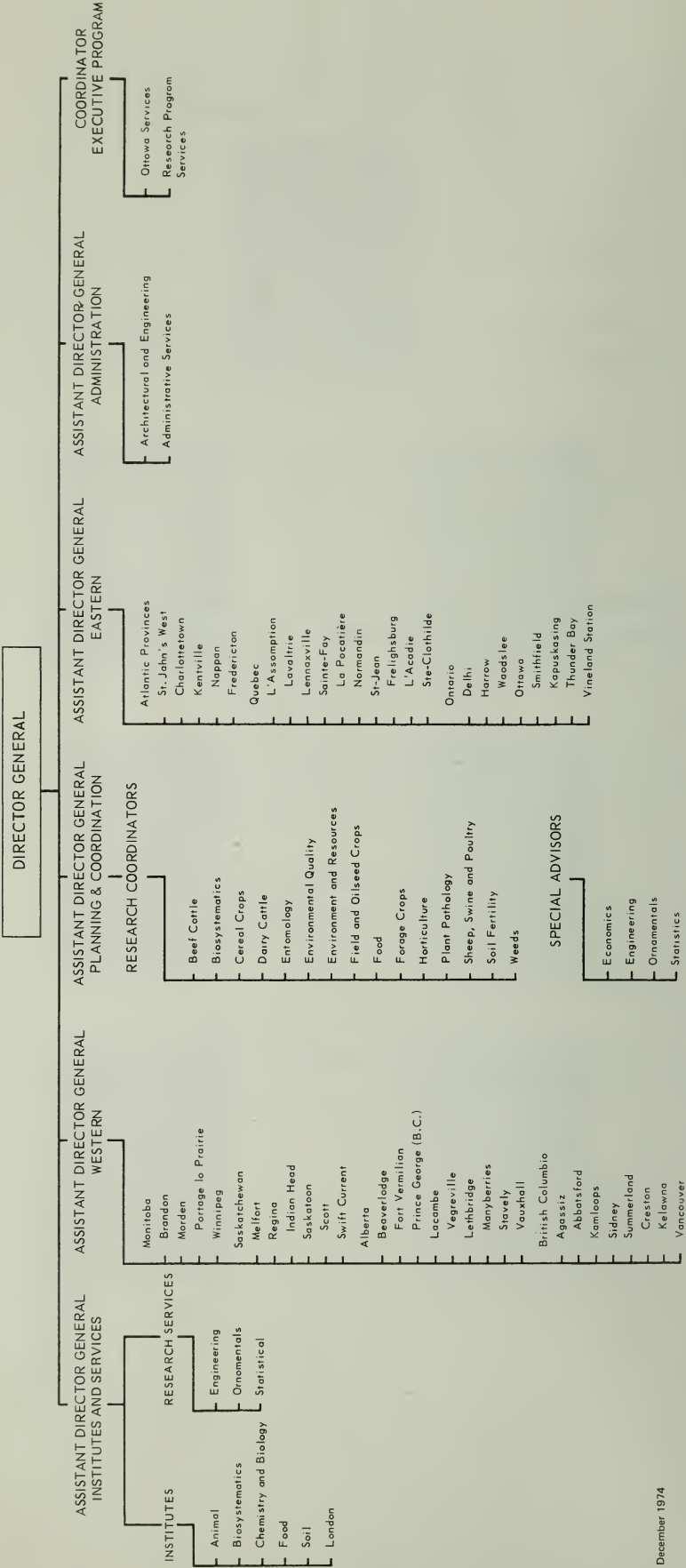
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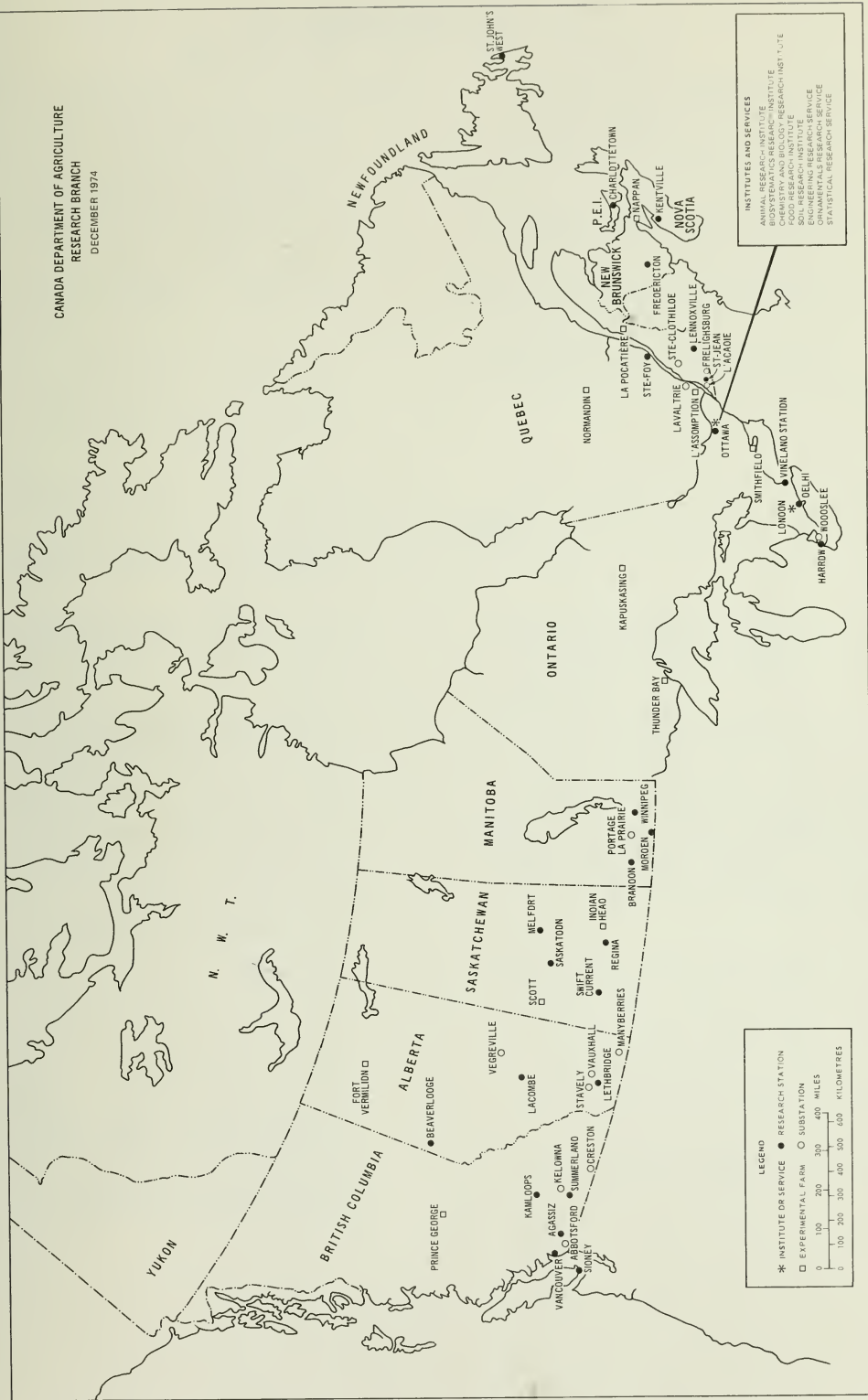
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CANADA DEPARTMENT OF AGRICULTURE RESEARCH BRANCH



CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH
DECEMBER 1974



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LEGEND

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□ EXPERIMENTAL FARM ○ SUBSTATION

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FOREWORD

The Research Branch report for 1974 is a compilation of the reports prepared by all the research establishments. Each report is a summary of the research activities conducted by the scientists and support staff of that particular station, institute, or service.

This 1974 report, together with all previous reports, represents a historical account of the progress of research in agriculture as conducted by the Research Branch of Agriculture Canada.

It will be noted that the Director of each establishment includes in the report his own introduction, which states summarily the part of the overall Research Branch program for which he is responsible. All the establishments conduct programs that are, to a greater or lesser degree, of national interest. In addition, most of the stations also direct their efforts to regional and local problems.

The research program plans are a result of the combined deliberations by the Planning and Coordination group at headquarters, the Directors and staffs of the research establishments, and the Research Branch Executive. It is the task of the Director General and Assistant Directors General to ensure that programs are conducted according to plan and are in concert with the objectives and goals of the Branch. The responsibility for how the research is conducted remains with the Directors and scientists of the establishments. Thus, this report represents a brief

summary of the research carried out by the scientists of the Research Branch establishments.

The results and activities reported in this publication are all interrelated and constitute a cohesive agricultural research program. A companion report, prepared by the Planning and Coordination group, is also published each year. This report reviews the Research Branch programs according to objectives and goals. It clearly demonstrates the existence of a coherent Research Branch program to which contributions are made by all research establishments located in Canada from coast to coast.

Two changes in management personnel took place during the year. The research coordination staff was strengthened by the appointment of Dr. R. R. Riel, as Research Coordinator (Food). Dr. J. Holme was appointed Director of the Food Research Institute.

The increased emphasis on global food production has stimulated interest in agricultural research by numerous agencies other than Agriculture Canada. This interest emphasizes the need for cooperative activity and coordination of research programs conducted by all organizations involved in research of importance to agriculture.

B. B. Migicovsky
Director General

AVANT-PROPOS

Le rapport de la Direction de la recherche de 1974 est constitué de l'ensemble des rapports préparés par tous les établissements de recherche. Chacun de ceux-ci est un résumé des activités menées par les chercheurs et le personnel de soutien de chaque station, institut ou service.

Le rapport de 1974, comme ceux qui l'ont précédé, rend compte de l'évolution de la recherche en agriculture telle qu'elle a été menée par la Direction de la recherche du ministère de l'Agriculture du Canada.

On notera que le directeur de chaque établissement présente dans son rapport sa propre introduction exposant sommairement la tâche qui lui revient dans l'ensemble du programme de la Direction de la recherche. Certains établissements ont des programmes qui sont, à des niveaux divers, d'intérêt national. De plus, la plupart des stations orientent leurs efforts vers la solution des problèmes locaux et régionaux.

La planification du programme de recherche est le fruit des délibérations tenues entre le groupe de la coordination et de la planification du bureau central, les directeurs et les employés des établissements de recherche et les administrateurs de la Direction de la recherche. Le Directeur Général et les Directeurs Généraux adjoints ont la tâche de veiller à ce que les programmes soient menés selon le plan établi et qu'ils soient conformes aux objectifs et buts fixés par la Direction. Il appartient aux directeurs et aux chercheurs des établissements de déterminer les modalités d'exécution des recherches. Ainsi, ce

rapport comporte un bref résumé des recherches effectuées par les chercheurs de chacun des établissements.

Les résultats et les activités décrits dans cette publication sont reliés entre eux et s'inscrivent dans le cadre d'un programme de recherche agricole cohérent. Le groupe de la planification et de la coordination prépare d'autre part un rapport complémentaire publié annuellement dans lequel il passe en revue les programmes de la Direction selon les objectifs et les buts. Il démontre clairement la cohérence des éléments du programme global auquel collaborent tous les établissements de recherche du pays.

Deux modifications ont touché le personnel de direction au cours de l'année. Le personnel de la coordination de la recherche a été renforcé par l'arrivée du Dr R. R. Riel au poste de coordonnateur des recherches (technologie alimentaire). Le Dr J. Holme a été nommé directeur de l'Institut de recherche sur les aliments.

L'importance accrue de la production alimentaire globale a stimulé l'intérêt de nombreux organismes autres que le ministère de l'Agriculture pour la recherche agricole. Cet intérêt fait ressortir le besoin de coopération et de coordination des programmes menés à bien par tous les organismes se livrant à des recherches d'importance en agriculture.

Le Directeur Général
B. B. Migicovsky

Research Station St. John's West, Newfoundland

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Plant Breeding and Pathology Section

K. G. PROUDFOOT, B.Agr., M.Agr. Head of Section; Potato breeding
M. C. HAMPSON, B.Sc., M.Sc., Ph.D. Plant diseases

Soils and Agronomy

A. F. RAYMENT, B.Sc., M.Sc. Soil fertility

Departures

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Transferred to Soil Research Institute, Ottawa,
April 1974

M. D. SUDOM Pedology
Resigned March 1974

INTRODUCTION

The Research Station at St. John's West conducts continuing research on potato wart disease, clubroot, and the golden nematode, and is responsible for resolving all types of regional agricultural problems. The research program also includes experimental studies on insect control, plant diseases, plant nutrition, and suitable vegetable and forage varieties for production on peat and mineral soils. Responsibility for soil survey work was transferred to the Soil Research Institute, Ottawa, during the year.

This tenth report covers results of research work carried on in 1974. Previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H. W. R. Chancey
Director

SOIL SCIENCE

Mineral Soils

Fertility. Data obtained over 11 yr (1960–70) showed that the response of potato crops to potassium fertilizers fitted very well to the Mitscherlich function, $\log_{10} (A - Y) = \log_{10} A - Cx$, where A = maximum yield attained under the experimental conditions, Y = yield for individual levels of x , the total soil and fertilizer potassium, and C = a constant derived by experiment. In this case, a C value of 0.0035 (in units $\text{kg K}_2\text{O/ha}$) was found acceptable for three soil types studied. Although values of C ranged from 0.008 to 0.0065, the extremes were rare and could readily be eliminated on the basis of some growth-limiting factors other than potassium. Thus, extremes on either side were associated with suboptimal yields.

Peat Soils

Drainage. The combined effects of low permeability and high precipitation of Newfoundland peats require additional drainage, such as mole drains, to supplement that provided by a conventional ditch system. In a new drainage experiment, a German "Leichtraupe" ditcher was used to make narrow slit ditches, 60 cm deep and 10 cm wide. The ditches closed at the top under the weight of the bog, allowing free travel and cultivation on the surface. However, due to the fibrous structure of the peat, the bottoms of the ditches remain open sufficiently to channel drainage water into mains or feeder ditches. The action of the ditcher was satisfactory on peats that contained little woody material, but some major modifications were

obviously necessary for satisfactory ditching under local conditions.

PLANT SCIENCE

Forage Crops on Peat Soil

Pastures. Evidence was obtained to confirm our report in 1973 that lambs gained more weight on Kentucky bluegrass pasture than on reed canarygrass, and that there was little or no response to a monthly selenium supplement given as a drench. Also, withholding salt licks that contained cobalt during wet periods controlled scouring, a perennial problem on these pastures. However, when cobalt was withheld for a long period, pronounced symptoms of "Phalaris staggers" developed in animals pastured on reed canarygrass. This condition is caused by alkaloids in *Phalaris* and should not be confused with magnesium tetany, as was incorrectly stated in our last report.

Forage harvesting. We investigated the feasibility of using a dump trailer for bulk harvesting of silage or field-dried hay, or both. A hydraulic dump was installed in the light, tracked trailer previously described. A hay storage area enclosed with wire mesh and provided with drying flues was located below a cut bank reinforced to serve as a dumping ramp. A special tarpaulin was designed to cover the storage area. The basic concept was workable and reasonably efficient, but failure of the trailer's hydraulic system prevented a complete production test until the next season.

Weed control. Postemergence applications of glyphosate at 1.12–5.6 kg active ingredient (ai)/ha were tested on land infested with reed canarygrass, Kentucky bluegrass, and red and white clovers. Although rates in excess of 2.24 kg ai/ha gave faster control there was no difference between any of the treatments when final observations were made on September 13. All gave very good weed control and none had any noticeable effect on rutabagas, cabbage, or lettuce planted after application of the herbicide.

Weed Control on Mineral Soil

Rutabaga (var. York) and cabbage (var. Market Prize). Treatments included preplanting incorporated applications of trifluralin, napropamide (Devrinol; Stauffer Chemicals), and dinitramine, and preemergence applications of chlorthal, RP-23465 (May and Baker), and AC92553 (Cyanamid of Canada Ltd.). RP-23465 gave excellent weed control at a rate of 1.12 kg ai/ha but reduced the crop stand to 20–30%. All other treatments failed to control the heavy stand of shepherd's-purse.

Greenhouse Crops

Tomatoes and cucumbers. Preliminary results at Happy Valley, Labrador, with cucumbers and tomatoes were promising in spite of the short growing season and the late seeding date (May 15). Cucumber yields were 12.0 and 12.6 kg/plant for HG70.72 and Toska 70. Tomato yields were 3.6 and 3.7 kg/plant for Ohio MR12 Pink Forcing and Vantage.

Tomatoes. Tests were conducted at St. John's West to confirm that the system of growing tomatoes in sawdust developed in British Columbia would be successful with local fir and spruce sawdust, and to determine the yields that could be expected from sequential plantings with a maximum of 2 wk of artificial light. Vantage and Vendor tomatoes were planted at approximately monthly intervals starting in January. Marketable yields in kg/plant for the first three plantings (Jan., Feb., and Mar.) were: Vantage 4.0, Vendor 4.4; Vantage 3.8, Vendor 4.0; and Vantage 3.8, Vendor 2.6. Results are not yet available from all plantings, but these are satisfactory.

Field Crops

Vegetables. Thirteen of the more common vegetables were tested at Happy Valley, Labrador. Planting was late (June 17) and yields of all vegetables except early cabbage, radish, onion sets, peas, and rutabagas were very low. Judging by the fast growth rate of these crops, an earlier planting date (June 1) would have produced better yields.

ENTOMOLOGY

Cabbage Maggot

Pelleting seed of York swede turnip with carbofuran (3.4 kg wettable powder) at 210 and 280 g/100 g of seed gave 97 and 95% control of root maggots, but caused 35 and 53% reduction in seedlings. A pelleted mixture of 40 g carbofuran plus charcoal and captan gave 88% control but reduced seedlings by 30%. Carbofuran at 70 and 140 g/100 g seed gave 75 and 74% control and reduced phytotoxicity to 10 and 11%. Because of a light infestation, marketable yields were not significantly improved by the treatments.

3M Sector I Yellow insect traps with Zoecon Cabmaggottract attractant gave 17–23% control of root maggots in rutabagas. Traps at a density of 548/ha were more effective than at 274 or 822/ha. Traps with attractant captured an average of 136–170 root maggot flies per trap during the season. The sex ratio was 1 male to 1.1 females.

Golden Nematode

In an evaluation of nematocide treatments, carbofuran 10 granular (G) at 6.72 kg/ha was most effective in preventing larval development in potato roots (13 larvae/3-g sample). Oxamyl 10 G at 13.4 kg/ha was nearly as effective, with 17 larvae/3-g root sample. Fensulfothion 15 G at 22.4 kg/ha, aldicarb 10 G, benomyl 2.27 kg emulsifiable concentrate (EC), and oxamyl 0.9 kg EC were less effective in controlling larval invasion of potato rootlets. Control samples contained an average of 140 larvae to a 3-g sample. The reductions of larvae in the roots were not reflected in crop yield and no detrimental effects from the nematode were observed in any of the plots.

Slug Control

Traps baited with 10 g of 2% methiocarb flakes (Mesurol; Chemagro Chemicals), caught twice as many slugs as traps baited with 10 g of 2.75% metaldehyde pellets (Slug-em; Commercial Solvents Corp.) during a period of 10 consecutive days (1.8 vs. 0.9). Methiocarb was also slightly more effective than metaldehyde in baited cages that contained a cabbage and 10 living slugs.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and Golden Nematode

In yield trials, selection N344-10 (bred from Mira and Sable) performed similarly to Kennebec but tubers were much more attractive in shape and more uniformly sized. Yields of N135-55, which was included in demonstration plots and trials across the island, were satisfactory at most centers although poor plant stand reduced yields in the Cormack area. In a seed plot of this selection at the Research Station, damage by *Rhizoctonia solani* Kühn was more prevalent than in an adjacent plot of Pink Pearl. However, this seedling will be licensed and adequate seed stocks of N135-55 will be available for growers in 1975.

Hudson, a variety from New York State resistant to the golden nematode, was included in several trials and high yields were obtained. This variety has also been included as a parent in the breeding program. Attempts were made to combine the race-specific resistance to wart, present in such varieties as Mira, with the high levels of field resistance present in some selections derived mainly from Katahdin. Crosses have been made between Mira and a range of selections from the breeding program at Fredericton.

Brassica Breeding for Resistance to Clubroot

F₁ hybrids resulting from crosses between the New Zealand turnip York and several breeding lines of rutabagas were planted in a clubroot-infested field plot. Growth was satisfactory and resistant roots have been

selected. Nodulation on some roots was pronounced and leaf damage from caterpillar feeding was more marked than in rutabaga seedlings growing in adjacent plots.

Germination and Infectivity of Potato Wart Sporangia

Inoculations with sporangia of race 2 were as successful as using inocula of race 1 after the sporangia had been air dried for several months. Acetone desiccation, however, prevented infection. When tumors were sampled for sporangia, fresh tissue slices yielded more, and more consistent, numbers of sporangia than did pieces of dried tumor or cork-bored tumor plugs. Up to 15 mm, sprout length bore a 1:1 relationship with sprout surface area; therefore, sprout length is a useful parameter of infection.

When potatoes were raised in infested greenhouse soil under differential irrigation patterns of 1, 2, or 3 wk of heavy watering applied 1 mo apart after planting, a bimodal infection curve developed with a massive peak in spring and a small one in late summer. When the three regimes were applied during the same month, a trimodal curve developed with peaks in the spring, late summer, and fall.

Contamination of culture dishes of sporangia was brought under control by a 0.025% solution of Thimerosal (Elanco Div. of Eli Lilly Co.). At this strength, Thimerosal did not appear to hinder either developmental phases of sporangia or assay using secondary fluorescence.

When used in concentrated form, hot ethanolic extracts of plant parts from susceptible and immune varieties apparently stimulated maturation processes in sporangia. pH-adjusted solutions and concentrated soil-plant leachates appeared to be less stimulating than did plant extracts (leachates > pH solutions). The effects of pH on sporangial physiology were apparent only at the extremes of the range studied (pH 3.51-11.1). No apparent differences in response between races 2 and 8 were noted. In maturation responses, fresh sporangia responded less than did medium-aged sporangia (average 50 days); old sporangia (> 98 days) were most responsive. The results suggested that germination processes of viable sporangia are very slow.

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Research Station

Charlottetown, Prince Edward Island

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¹Seconded from Economics Branch.

INTRODUCTION

The Research Station at Charlottetown has regional responsibility for research into the production of forages, cereals, tobacco, and vegetable crops grown for processing. Research is also conducted on local problems with potatoes, cattle nutrition and breeding, and small fruits. This report summarizes the results from selected research projects; further information on the results presented, or on other aspects of the research program, may be obtained from the Station or individual scientists. Copies of this report and reprints of the scientific papers listed may be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L. B. MacLeod
Director

CEREALS

Breeding and Testing

Barley. Kinkora, the first and only commercial variety of barley that is resistant to the barley jointworm, *Tetramesa hordei* (Harris), was licensed. In addition to jointworm resistance, Kinkora has smut resistance similar to Conquest, but is susceptible to the recently identified strains of *Ustilago nuda* (Jens.) Rostr., which are virulent on cultivars derived from Jet. It has moderate resistance to scald and to soils with low pH. Under severe jointworm infestation, Kinkora yielded 4372 kg/ha, whereas Volla and Charlottetown 80, two highly susceptible varieties, yielded 897 kg/ha.

Two European varieties, Diva and Lud, and several breeding lines from Charlottetown performed well, producing high yield and showing resistance to lodging. These varieties have not been licensed yet in Canada.

Winter wheat. The selection WW1001-1 continued to yield well in comparative trials. It has greater hardiness, higher test weight, and heavier kernel weight than the present recommended varieties. It outyields Yorkstar in years when winterkilling is a problem. It is resistant to sprouting in the head. It will be considered for licensing in 1975.

Fall rye. Excellent yield potential of fall rye was shown by several varieties that produced more than 100 q/ha in comparative trials. Several lines from Poland outyielded Kustro. Two F_1 composite populations of rye were initiated with emphasis on combining winterhardiness, shorter straw, and yield.

Fababeans. Fababeans showed potential as a protein crop by producing up to 1700 kg of protein/ha. The crude protein content of seed was 28–33%. The highest yielding cultivar, Herra, produced 5268 kg of seed/ha, which was 100 kg/ha more than Diana and 430 kg/ha more than Herz-Freza, the earliest maturing cultivar.

Management and Nutrition

Potential for expansion of crops and livestock production in the Maritimes. A model of Maritime agricultural production was used to examine the physical possibilities of expanding cereal and protein production to provide the feed for enough livestock to meet the regional demands. Although there appears to be ample physical opportunity to expand crop and livestock production in the Maritimes, the economic merits of expansion depend to a large extent upon the prices of imported cereals and the efficiency of local production.

Economics of labor-machinery substitution in seeding operations. The economic implications of substituting labor for machinery in tillage and seeding operations were examined. For most combinations of values in the likely ranges of costs for machinery, timeliness penalty, and labor, there was a very wide range of machinery system sizes (and hence labor inputs) that provided a total cost per hectare within 10% of the cost at the least-cost size. However, the minimum cost per hectare varied considerably with the cost of machinery (or cultural practice selected) and the extent of the timeliness penalty arising from delayed seeding.

Least-cost combine size. The cost of harvesting cereal was found to vary from \$30/ha to \$86/ha for combine sizes of 4.5 t/h to 11.5 t/h on areas of 40 to 121 ha. The costs included buying and operating the combine, labor, natural crop loss that occurs after the optimum time of harvest has passed, and loss of the crop due to combine (header and tail losses).

The least-cost combine for 81 ha, a crop value of \$88/t, and a crop loss of 33.5 kg/ha per day was found to be the combine with a capacity of 6.75 t/h. In this situation, the estimated harvesting cost was \$39.50/ha.

Herbicide-N solution combinations for cereals. Delaying application of part of the N requirement of spring wheat until the 4- to 5-leaf stage usually resulted in slightly higher yields and higher protein levels. Studies showed that N at up to 22 kg/ha applied as a urea - ammonium nitrate solution in combination with either 2,4-D or MCPA gave weed control similar to that obtained with a conventional herbicide. By using the herbicide-N solution combination, it was possible to make a delayed N application without an additional field operation.

Control of hemp-nettle in cereals. Amine salt and estemine formulations of MCPA at 0.56 litre ai/ha and 0.84 litre ai/ha were applied postemergence to hemp-nettle in the 4- or 6-leaf stage. The amine formulation gave greater control than the salt formulation, which was better than the estemine formulation when the lower rate was applied at the 4-leaf stage. There were no differences in hemp-nettle control between formulations with the lower rate of application at the 6-leaf stage and those with the higher rate applied at the 4- or 6-leaf stage.

Sources of N and P for cereals. Severe damage to wheat, oats, and barley seedlings was observed when fertilizer containing urea and diammonium phosphate was drilled with the seed on Culloden sandy loam. Much less damage was observed from urea with triple superphosphate. No damage was evident when fertilizers containing ammonium nitrate and triple superphosphate or ammonium nitrate and diammonium phosphate were drilled.

Symptoms of sulfur deficiency in crops. Sulfur deficiency was induced in cauliflower, rutabagas, wheat, barley, and alfalfa in a greenhouse by continuous cropping on the

same soil, with no added S. Yellowing of entire plants and burning and scorching of leaf edges were the two most distinguishing features of S deficiency observed.

Diseases

Seed source and treatment. Barley seed produced in Western Canada had a much lower level of contamination by *Helminthosporium* spores than seed produced in Eastern Canada. Seed treatment with Vitaflo (UniRoyal Chemicals) increased the yields from eastern-grown seed to a level comparable with that produced by western seed. Yields of Keystone and Volla barley were improved to such an extent by seed treatment that treating all eastern-grown barley seed before planting is recommended.

FORAGES

Physiology and Management

Winter survival of alfalfa. Alfalfa survived the 1973-74 winter season with 20% or less winterkill in Nova Scotia and Prince Edward Island. Severe winterkill of alfalfa occurred in New Brunswick, where 80% or more of the crop was lost. In the first week of April, only 10% of sample plants taken from New Brunswick were viable and no heaving was observed. By the last week of April, however, extensive heaving of taproots was observed. Because lethal damage had occurred before heaving was observed, the heaving may have been the result rather than the cause of winter injury. In a cold-room experiment, it was found that Saranac alfalfa plants can survive 2 mo under a 5-cm-thick ice sheet cover with little damage to the plants when they were grown in a dry soil having a moisture level as low as 40% of field capacity.

Viability of overwintering plants. The most reliable method for estimating viability of overwintering plants was a test in which the percentage of survival was determined on sample plants transplanted from the field and grown for 3 wk in a greenhouse. For forage crops and winter cereals, the accuracy and speed of estimating viability using fluorescein diacetate (FDA) were best, followed by triphenyl tetrazolium chloride (TTC). For strawberry plants the use of TTC was as accurate as or better than the FDA method.

Irrigation of pastures. In a grazing experiment conducted on a light sandy loam for 5 yr, sprinkler-irrigation plots consistently out-yielded nonirrigated plots, except in the late fall, when moisture was adequate and a treatment on September 1 of N at 56 kg/ha was applied. The average annual dry matter (DM) production of pasture swards consisting of timothy, Kentucky bluegrass, and wild white clover was 14.04 t/ha for irrigated plots and 12.63 t/ha for nonirrigated. Irrigation increased the average DM production 1.72 t/ha on the zero N plots. Yields on irrigated plots increased linearly as the levels of N were increased; the largest increase was 4.21 t/ha, attained after the split application of N at 280 kg/ha (56 kg in early spring, 84 on June 15, 84 on August 1, and 56 on September 1).

Effect of stage of maturity of timothy at harvest on costs of feeder cattle rations. Rations based on timothy harvested at stages of maturity from vegetative to flowering were formulated for several classes of beef cattle whose average daily gain and length of keep varied widely. The stage of maturity of timothy at harvest that leads to minimum feed costs differed substantially as a function of cattle class and the price of the cereal component of the rations. The feed costs for various stages of maturity of timothy ranged from \$9/head for short-keep animals fed to gain 1.1 kg/day to \$38/head for wintering animals fed to gain 0.57 kg/day when barley cost \$110/t. These differences were \$3/head for short-keep animals and \$10/head for wintering animals when barley cost \$55/t.

Cutting management of grasses. Total DM yields of timothy, brome grass, and orchardgrass increased until the flowering stage and ranged from 4370 to 11 840 kg/ha. Aftermath DM yield rarely exceeded 3500 kg/ha. Stand persistence was satisfactory under all cutting managements. Percent in vitro digestible dry matter (IVDDM) of primary growth varied from 76.5 to 37.0. The IVDDM of primary growth declined from 0.69% to 0.82% per day for 24 days. The IVDDM of aftermath tended to be inversely related to the length of the regrowth period. Percent crude protein (CP) of primary growth was 18.2–7.1 under various cutting managements and decreased at an average daily rate of 0.33–0.37. Percent CP of aftermath was 15.0–9.6.

Cereals as whole crop forage. In 1 out of 3 yr, applied N substantially increased DM yields and CP concentrations of whole crop barley, oats, and triticale harvested at the early-dough stage. Yields of cereal forage were 3090–10 190 kg/ha, depending on year, species, and amount of N applied. Split applications of N were not any more effective than single applications in increasing CP concentrations. Whole crop barley, triticale, and oats had mean IVDDM of 46.9–58.3%. High rates (200 kg/ha) of N tended to result in accumulation of potentially toxic levels (0.2% or higher) of $\text{NO}_3\text{-N}$, particularly in oat and barley forages.

Corn management. Yields of silage corn DM increased until the first killing frost in late September and then declined progressively thereafter. The percent digestible DM of the material harvested in 1973 also declined progressively after frost. Lodging increased in severity with time after frost. Better yields and maturity were obtained when corn for silage was planted from mid- to late May, but plantings later than early June produced much lower yields. However, early plantings suffered greater germination losses. In 1974, one-third less seedlings emerged on a plot planted on May 16 than on one planted May 31. Field populations of 54,000–69,000 plants/ha gave satisfactory yields and maturity.

Establishment of alfalfa. N fertilization at seeding was not usually needed to establish vigorous alfalfa stands. Applied N produced small increases in the DM yields of alfalfa in the first harvest only. The DM yields of alfalfa without any weed control were 2–64% lower than those of hand-weeded plots. Embutox E (May and Baker (Canada) Ltd.) plus dalapon tended to lower the DM yields of alfalfa. Yields of the first harvest in two out of three trials contained less than 30% weeds when no weed control was used.

Control of barnyard grass in field corn. Alachlor at 2.24 kg ai/ha gave longer-lasting and better control of barnyard grass than cyanazine at 2.24 kg ai/ha, which was better than atrazine at 1.68 kg ai/ha when either cyanazine or atrazine was used alone before field corn and barnyard grass emerged or early postemergence (when barnyard grass had two leaves). Combinations of alachlor or cyanazine with atrazine gave excellent control of barnyard grass all season, even when

applied at late postemergence (when barnyard grass had four leaves). The combinations of pesticides applied late postemergence, however, severely injured the corn.

Time of glyphosate application and control of quack grass. Glyphosate at 1.12 kg ai/ha applied to quack grass, *Agropyron repens* (L.) Beauv., at the 4–5-leaf, 6–7-leaf, or flowering stages gave 95% control of shoot and rhizome growth in the greenhouse, but at the 1–3-leaf stage, however, gave only 50% control of shoot and rhizome growth. There was no difference in control of quack grass when glyphosate was applied to shoots that had grown from 2-node or 10-node rhizome pieces. Control was 90% with both 2-node and 10-node rhizome pieces when application was made at the 4-leaf stage but only 20% with application at the 2-leaf stage.

Nutrition

Molybdenum, copper, and sulfur relationships in forages. With up to 0.2 ppm Mo applied to the soil, 5.7–11.5 ppm Cu, 0.15–0.21% S, and 0.22–3.92 ppm Mo in timothy and red clover, plants were safe for consumption by animals. Toxic levels of Mo in red clover and timothy that resulted from applications of 1 ppm Mo to the soil were alleviated in most cases by applying S at 50 ppm.

Banded phosphorus sources for establishing alfalfa. Banding P at 25 kg/ha below the seed improved alfalfa establishment. Diammonium phosphate was superior to monoammonium phosphate, which was superior to triple superphosphate.

Corn fertility. Yields of DM increased significantly when N was applied at 45 kg/ha to silage corn growing for the first time and at 90 kg/ha when growing for the third year in the same location. Yields also increased when K was applied at 37 kg/ha and P at 25 kg/ha at one first-year and one third-year location. Yields responded to P at 50 kg/ha at another location, but no yield responses resulted from the addition of K. Yield increases were usually accompanied by improved maturity of the grain component of the silage. Higher fertility rates of N up to 180 kg/ha, P to 100 kg, and K to 150 kg did not affect yields or maturity.

Insects and Nematodes

Bronzed cutworm in the Tantramar Marsh. The bronzed cutworm, *Nephelodes emmedonia* (Cramer), appeared in near-epidemic numbers in the Tantramar Marsh, New Brunswick, in 1974. However, before serious damage to grasses could occur, predators, parasites, or disease reduced the population markedly. Granulosis virus was not recovered from the dying specimens, but a microsporidian disease was detected in some specimens. Six insecticidal sprays effectively reduced populations of the cutworm in a field trial.

New alfalfa insect. The alfalfa blotch leafminer, *Agromyza frontella* (Rondani), was identified for the first time in the Atlantic region as a potentially serious pest of alfalfa.

New timothy pest. The European skipper, *Thymelicus lineola* (Ochsenheimer), was identified as a potentially serious pest of timothy and other grasses in Prince Edward Island.

Nematodes in forage legumes. The identity has been confirmed of 18 species in 10 genera of potentially parasitic nematodes associated with forage legumes in New Brunswick. *Pratylenchus crenatus* Loof was found more often than *P. penetrans* (Cobb) in New Brunswick and more often than comparable samples in Prince Edward Island.

Root-knot nematode affects forage legumes. Of five forage legumes inoculated in the greenhouse with the northern root-knot nematode, *Meloidogyne hapla* Chitwood, sainfoin was the most susceptible and crownvetch the least; alfalfa, red clover, and birdsfoot trefoil were intermediate. Nematode inoculation decreased foliage yields of sainfoin and red clover more than of the other legumes. Sainfoin was the only forage legume that died when inoculated with the root-knot nematode.

Population dynamics of root-lesion nematodes. Four generations of *P. penetrans*, each lasting about 6 wk, occurred after the nematodes invaded the roots of red clover in the seeding year. The average numbers of nematodes per plant in each generation in order were 40, 579, 1534, and 3510.

Corn insects. One application of the granular insecticides fonofos, carbofuran, diazinon, or fensulfothion applied at the whorl stage was as effective as three spray treatments with either carbofuran, Pencap E (Pennwalt Corp.), or carbaryl in reducing larvae and larval tunnels of the European corn borer, *Ostrinia nubilalis* (Hubner), in field corn. Although total silage yields were not significantly increased, several of the treatments resulted in significantly increased grain yields over the untreated controls. DeKalb 22, Cargill 185, and Stewart's 3502 hybrids exhibited partial resistance to attack by the borer. No difference in corn-borer infestation was observed between plots plowed in the spring and those plowed in the fall.

HORTICULTURAL CROPS

Potato Nutrition and Management

Fertilizers, seeding dates, and plant spacings. Urea or ammonium nitrate in combination with triple superphosphate or diammonium phosphate were equally good sources of N for potatoes. Rates of N as high as 200 kg/ha were used. Plant emergence and growth were not affected by N source. The cool, moist soil conditions in the spring prevented buildup of toxic levels of ammonia from the urea and diammonium phosphate. Total yields and yields of large tubers increased as the rate of N increased. As plant spacing was increased from 28 to 46 cm for Netted Gem and from 20 to 38 cm for Kennebec, the yield of large tubers increased and small ones decreased, but the total yields were unaffected. Late planting decreased tuber size in Netted Gem but increased it slightly in Kennebec. Tuber sp gr decreased somewhat with late planting. Low temperatures in spring delayed emergence of early plantings by 12–14 days, which minimized effects of planting dates.

Magnesium sources compared. No yield responses were obtained when Mg from various sources was applied to potatoes, tobacco, or field beans grown on soils low in Mg (< 40 ppm). Some yield responses were noted in the greenhouse with beans and ryegrass. Uptake by plant tissue indicated the following relative availability of Mg from various sources: $\text{MgSO}_4 = \text{K}_2\text{SO}_4 \cdot 2\text{MgSO}_4$

> dolomitic limestone > MgO. Dolomitic grits provided no available Mg to plants.

Potato Diseases and Insects

Control of late blight. In a study on the effects of the shape and size of plots, it was found that less positive interplot interference in fungicide control of potato late blight, *Phytophthora infestans* (Mont.) de Bary, occurred among long, narrow plots than among wide, square plots.

Under conditions that prevailed in 1974, adequate control of late blight was provided by the fungicides chlorothalonil, mancozeb, fentin, and the confidential materials CGF 2660 (Ciba-Geigy Canada Ltd.), RH6-356 (Rohm & Haas Company of Canada Ltd.), and TF 3288 (Chipman Chemical Ltd.). The test product FMC 28221 (FMC of Canada Ltd.) was not efficient. The dinoseb product INT-174 (Interprovincial Co-Operatives Ltd.) was found to be an effective potato top killer.

Control of potato viruses. Over 10,000 tubers were eye-indexed for detection of potato leaf-roll virus, and another 3000 were tested serologically or on indicator plants for potato viruses S (PVS), X (PVX), and Y (PVY). Four tubers were found infected with leaf-roll in the index work; no PVX or PVY were found in the serological work, but slightly less than 1% of the tubers were infected with PVS. Results from 1400 tests of Pre-elite stocks at the Prince Edward Island seed farm showed 1% infection with PVS and none with PVX.

Spread of viruses S and X. No spread of PVS or PVX occurred in the Kennebec variety of field trials. No spread of PVX was found in Sebago, but 13.5% of the plants became infected with PVS.

Aphid studies. Yellow pan trappings and actual counts on potato plants from five locations on Prince Edward Island showed that nearly 14 times more potato aphids were present than peach aphids. The largest populations were present in August, and the potato species arrived in potato fields earlier than the peach species.

Vegetable Nutrition and Management

Nitrogen applications for Brussels sprouts. Applications of N in two bands, on both sides of the row about 15 cm apart and about 8 cm below the soil surface, resulted in as

great or greater yields of Brussels sprouts than either broadcast applications or broadcast plus topdressing. Optimum yields were obtained where N was applied at 112 kg/ha.

Cultivars and spacing for single-harvesting of broccoli. In experiments conducted with several cultivars during three seasons, yields generally increased and spear weight decreased as the distance between plants decreased. Cultivars differed considerably in maturity and percentage of marketable spears in response to spacing. The best cultivars tested for single-harvesting were Green Duke, Blue Ocean, S & G No. 1, and Atlantic, and the best spacings were 30 × 30 cm to 40 × 40 cm.

Boron deficiency in cole crops. In field experiments conducted on a fine sandy loam containing 0.28 ppm available B, broccoli and cauliflower responded to added B. An application of 1 ppm B to the soil increased the yield of broccoli and Brussels sprouts by 20%. However, B-deficiency symptoms were observed only on broccoli in the form of browning of older leaf edges. A lack of response to B on Brussels sprouts indicated that this crop is less sensitive to B deficiency than are broccoli or cauliflower.

Vegetable Insects and Diseases

Bioactivity of new insecticides. The insecticides that showed the highest level of toxicity within 30 days after application (e.g., Counter (Cyanamid of Canada Ltd.), propoxur, and carbofuran) usually degraded fastest to nontoxic components. However, some materials were both initially and residually highly toxic (e.g., CGA12223 (Ciba-Geigy Ltd.), chlorpyrifos, and fonofos), depending on method of application. The most persistent compounds showed the lowest levels of initial toxicity, and toxicants of compounds such as phoxim and trichloronat gradually increased during most of the growing season in the soil and throughout the whole growing season in plant tissue.

When mixed with the soil or banded 2.5–5 cm below the soil surface, all materials differed quite markedly either in their level of toxicity at a given time after application or in their rate of absorption into plant tissue and subsequent rate of degradation to nontoxic moieties. For example, Counter was slightly more toxic per unit than phorate, and higher levels of toxicants persisted longer in the soil. However, phorate toxicants were

higher and persisted longer in plant tissue, both in the field and in storage. When banded below the soil surface, persistent compounds such as phoxim were too slowly bioactivated to control root maggots in crucifers during early to midseason attacks but gave good control of attacks in late summer and fall. Also, toxic residues slowly accumulated in roots during the growing season and were very slowly degraded in roots in storage. CGA12223 was the most efficient material tested for control of root maggots in 1974.

Pea diseases. Disease surveys of pea fields have shown the importance of both the *Ascochyta* and root-rot diseases. Crops with visible damage caused by disease may show losses of up to 80% of potential yield, whereas healthy-appearing fields may lose up to 20% of expected yield. Fungicide seed treatments improved stands and yield of field peas. Disease severity of field peas was reduced and yields were increased by planting enough grain crops with the peas to hold the peas above ground level.

Strawberry Nutrition

Effect of N, P, and K on strawberry yields. Broadcast applications of N and P increased the yields of strawberries in the first and second fruiting years, whereas applications of K had very little effect. The fertilizer treatments were applied 6 wk after transplanting and immediately after the first harvest season. Optimum yields were obtained where N was applied at 90–180 kg/ha and P at 200 kg/ha.

TOBACCO

Nitrogen requirements for flue-cured tobacco. Based on soil tests, optimum N requirements for growing tobacco in soils with organic matter levels below 2.0% were 26–30 kg/ha. Highest tobacco yields and dollar returns per hectare, however, were obtained when N at 34.7–43.7 kg/ha was applied, indicating an increased demand for N above predicted amounts when soil organic matter levels were below 2.0%.

CATTLE

Rye rations for steers. Grain rations containing 0%, 40%, 60%, and 80% ergot-free rye, fed free-choice to steers along with restricted amounts of corn silage and hay, did not affect feed intake. Barley-fed steers gained 1.5 kg/day, whereas those on the rye rations averaged 1.3–1.4 kg/day. These data indicate that up to 80% ergot-free rye can be included in the grain ration without affecting intake and with only a slight reduction in rate of gain.

Age of dairy calves at weaning. Ayrshire bull calves that had been fed whole milk with free access to dry calf starter were weaned abruptly at 2, 3, and 5 wk old onto a dry starter feed. From birth to 15 wk old, liveweight gains were 0.41, 0.45, and 0.41 kg/day with intakes of dry feed of 154.5, 161.2, and 130.2 kg for the 2-, 3-, and 5-wk weaning ages. The calves weaned at 3 wk ate more starter ration than the calves weaned at 2 wk, which explains their better performance. This study showed that weaning at 3

wk of age can be successful, but that some calves may not adapt to weaning at 2 wk of age.

Selenium content of feedstuffs produced in the Atlantic Provinces. Analyses of forage samples from the four Atlantic Provinces indicated that all samples except those from several locations in Nova Scotia contained less than 0.1 ppm selenium and were Se deficient. These data were consistent with the widespread reports of white muscle disease in beef calves and stiff-lamb disease throughout the region.

Evaluation of pastures for growing steers. Pasture plots seeded to timothy, orchardgrass, and meadow fescue were compared with permanent pasture having a Kentucky bluegrass – wild white clover sward for growing steers. The average liveweight gains were 629.4, 603.7, 549.9, and 605.9 kg/ha. Under the conditions of this experiment, with ample rainfall, high fertility, and rotational grazing, the permanent pasture performed as well as the timothy and orchardgrass pastures.

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Research Station Kentville, Nova Scotia

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INTRODUCTION

This publication summarizes the main research results of the Research Station at Kentville and the associated Experimental Farm at Nappan for 1974. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km (50 miles) north of Kentville, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool, humid climate and Podzol soils.

On March 20, 1974, Premier Gerald A. Regan of Nova Scotia and the Honorable Eugene Whelan, Minister of Agriculture, jointly announced that a new laboratory and office complex would be built at the Kentville Station to house the extension services and the research facilities. This structure will aid the agricultural community of the area greatly. The firm of Leslie R. Fairn and Associates, Ltd., has been appointed as design consultant for the project.

Our staff was strengthened by the addition of two scientists during the year. Dr. K. B. McRae came to Kentville on May 17, 1974, from the Department of National Health and Welfare, Ottawa. He is responsible for experimental design and statistical procedures at all research stations in the Atlantic Provinces. Dr. D. B. Cumming came to Kentville on December 10, 1974, from the University of British Columbia, where he completed his doctoral thesis in food technology.

Copies of this chapter of the Research Branch Report and reprints of the listed publications are available on request from the Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5.

J. R. Wright
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush Blueberries and Cranberries

Lowbush blueberry fertilization. Plant growth and fruit production of seedlings and cuttings of lowbush blueberry with various N, P, and S soil treatments were compared. The addition of N alone did not improve plant stem growth, flower bud development, or numbers and weights of berries compared with results on unfertilized soils. Plants grown on P-treated soils had more numerous, longer stems than unfertilized plants and the highest number of flower buds in the experiment. Plants fertilized with N-P and P-S combinations produced the greatest number of berries per plant.

Surface mulch effect on plant growth. A mulch of sawdust was spread 5 cm deep on weed-free ground planted with select clones of lowbush blueberry. Increases in plant diameters and rhizome production after 2 yr have indicated a beneficial effect from the mulch. Soil erosion by water and wind was

reduced and winter frost-heaving was minimized on mulched areas.

Control of eastern bracken. The herbicide asulam (40%) applied at 2.8 and 5.6 kg/ha to eastern bracken at full frond gave 85% control in 1973 and 94% in 1974.

Fern plants on associated untreated areas grew vigorously and increased in number by 55% in 1974. Asulam is registered in Canada for the control of wild oats in flax. It is expected that registration for its use on bracken will be completed after assessment of reports in 1974.

Biology of bayberry. Bayberry is a native shrub occurring mainly along or near the seacoast of the Maritime Provinces. Bayberry grows on light sandy soils that are highly acidic and is the main weed in fields of lowbush blueberry (*Vaccinium angustifolium* Ait. and *V. myrtilloides* Michx.) developed on the Culloden soil series in Prince Edward Island. Lateral growth of bayberry occurs by rhizome, and after burning, new shoots grow from dormant buds of the stem or rhizome. Because the upper surface of bayberry leaves is waxy, the shrub is quite resistant to salt

spray and 2,4-D. The herbicide 2,4,5-T in oil applied to cut branches can control this weed.

Cranberry performance. During the past 2 yr the performance of the cranberry cultivar Ben Lear in Nova Scotia was disappointing, whereas the cultivar Stevens performed remarkably well. Fruit from Ben Lear matured at least 2 wk ahead of that from native selections and from Stevens, and exhibited excellent size and color. The problem with Ben Lear, however, was its poor productivity. About mid-July in 1972 and 1973 the terminal bud withered and a new one developed from the nearest adventitious bud. The second terminal bud never reached the same stage of development that was reached by the cultivar Stevens at the end of the growing season.

Strawberries

Breeding. A diallel of seven inbred clones of the domestic strawberry was evaluated for five variables and was compared with the standard cultivar Redcoat. Redcoat figures for fruit yield, berry weight, mean date of harvest, and area covered per clone were similar to the mean of the diallel. Unexpectedly, all seedling crosses produced more than twice as many runners as did Redcoat.

The additive component of variance was only 3.2% for fruit yield, but was 50.5, 83.0, 27.6, and 10.9% for berry weight, mean date of harvest, runner number per clone, and area covered per clone, respectively. Total fruit yield was significantly influenced by all of the other four variables, but the relationship was highly variable and did not present any consistent pattern. A cautious interpretation of results is required because of common parentage and inbreeding in the parental lines.

The results of this study are in general agreement with similar studies at North Carolina and Ottawa, but all three studies yielded results quite different from those of a California study in which a parent-offspring regression method of analysis was used. It appears that different methods of measuring genetic parameters may be as significant in causing this discrepancy as are differing methods of culture, range of cultivars, and climatic factors, which have been previously implicated.

A new virus disease. A check of the nuclear stock grown at the Research Station, Kentville, revealed that the latent virus disease

pallidosis was present in the cultivars Redcoat, Cavalier, Veestar, Vibrant, Raritan, and Midway. This disease was not found in the European cultivars Redgauntlet and Gorella. A new cultivar developed at Kentville, called Bounty, was free from the disease. Pallidosis was detected in excised leaf grafts to UC10, the University of California *Fragaria vesca* indicator. The principal symptoms are shortened petioles with pale, stunted leaflets showing epinasty, or cupping. Pallidosis is considered a potentially serious disease because when it is combined with other viruses a marked plant degeneration can result. The infected cultivars are being heat treated and the runner tips cultured in an attempt to produce pallidosis-free stock.

Cultivar Testing of Berry Crops

Testing has revealed several new cultivars of good potential value for the Atlantic Provinces. The strawberry cultivar Bounty has performed well from Quebec to Newfoundland. Second-year yields of fruit from experimental plots 60 cm wide in matted rows have exceeded 45 000 kg/ha.

The raspberry cultivar Festival, released by the Research Station, Ottawa, in 1971, has hardy canes and is productive. Other characteristics are short upright canes; strong fruiting laterals; and bright red, medium-sized, firm, good-quality berries suitable for home gardens or commercial production.

Northland, a lowbush-highbush blueberry hybrid introduced by Michigan State University in 1967, appears promising. By the third season after planting, yields exceeded 1 litre per bush. This early-fruiting, hardy cultivar appears useful for Eastern Canada.

The hybrid grape selection V53035 (Alden × Seibel 9110) of the Horticultural Research Institute of Ontario is hardy and productive in the Annapolis Valley. The white grapes of this variety make a nice white table wine.

Ornamentals

A new rhododendron cultivar. A rhododendron seedling from the cross *Rhododendron fortunei* Lindl. × *R. smirnowii* Trautv. was selected in 1974 and will be named Bellefontaine. This selection is a sibling of Evangeline, which was named in 1973. Bellefontaine is a surname used in Longfellow's poem *Evangeline*. Bellefontaine flowers a week earlier than Evangeline, but otherwise it resembles Evangeline closely. The flowers

are large, scented, and rose opal in color. The plant is winter-hardy and vigorous.

Apples

Hormones for ripening. The effects of ethephon applied at two dates at 0.62 and 1.25 litre/ha (0.5 and 1.0 pt/ac) and of daminozide at 13.2 kg/ha were tested on Crimson Gravenstein apples. Daminozide- and ethephon-treated apples bore more pronounced red overcolor than did untreated controls. Ethephon at 0.62 litre/ha was almost as effective as at 1.25 litre/ha. Fruit ripening after harvest was slowed by early picking and by the application of daminozide, and was accelerated by application of ethephon. However, no significant interaction was found between the two chemicals when both were applied to the same fruit.

Forage and Vegetable Crops

Weather effects on hay drying. Three consecutive good days were chosen as the standard for good hay-drying weather at Nappan, N.S. Based on 30 yr of weather records, the highest probability (36%) of having this good weather at Nappan occurs in the first 2 wk of July. Maximum production of digestible dry matter in hay occurs about mid-June. Rapid storage of high-quality forage is desirable. To facilitate harvest, early cuttings of forage should be taken as ensilage. An index based on potential evaporation and precipitation is proposed as a measure of the suitability of weather data for predicting field-drying rates. A good drying day was defined in terms of this index and used in the estimation of the probability of sequences of good drying days from 30 yr of weather data from Nappan, N.S.

Grasses for fall grazing. In 1971 three fields of 2.4 ha each of tall fescue, crested wheatgrass and Russian wild ryegrass, and timothy and brome grass were established to evaluate these species for pasture. Establishment was good for all species; couchgrass was the only significant weed present.

Tall fescue, crested wheatgrass, and Russian wild ryegrass may provide more nutritious grazing in late fall than does a mixture of timothy and brome grass. Digestibility of the 1st-year crops remained high throughout the late fall. This result could be attributed to immaturity, however, because timothy and brome grass also remained highly digestible in late fall.

Results indicated that the western-type grasses were not greatly superior to timothy or brome grass for late fall grazing. Animal gain was slightly greater on tall fescue than on other grasses that had been grazed until July 15, rested until September 15, and then grazed again until November 15. The least gain was made by animals grazing timothy and brome grass. It would appear that if the stand of the western grasses could be maintained, animal gains could be increased; but the competition from couchgrass and other weeds is very strong and rapidly reduces the seeded stands, which cancels their advantage.

The average daily gain of animals was greatest on the grasses grazed twice, where quality was better but percentage of seeded species was lower.

Effect of lime on field bean yields. Dolomitic limestone was applied at 0, 2240, and 4480 kg/ha to a Charlottetown fine sandy loam soil with a pH of 5.0–5.2. These applications increased the yield of field beans substantially. Applications of 2240 kg/ha each year for 2 yr resulted in greater yields than did a single application of 4480 kg/ha.

PROTECTION OF CROPS AGAINST PESTS

Plant Pathology

Apple and pear scab. Seasonal sprays of the benzimidazole-type fungicides at high dosages inhibited and at low dosages reduced the overwintering inoculum of apple scab fungus, *Venturia inaequalis* (Cke.) Wint. On spur apple leaves sprayed with Dikar (Rohm and Haas) the overwintering inoculum was reduced to a low level, whereas on extension-growth leaves, ascospore productivity increased as the age of the leaves on the extension shoots decreased.

In fungicide trials thiophanate-methyl, Bay Dam 18654 (Chemagro Corp.), and benomyl all gave excellent control of apple scab. It was possible to reduce the dosage required for control by adding a small quantity of superior oil to the spray mixture. Thiophanate-methyl at 35.2 g ai (active ingredient) per hectolitre was very effective against pear scab, *Venturia pirina* Aderh., on the cultivars Clapp Favorite and Flemish Beauty. This rate was much more effective than a rate of 26.4 g/hl. Bay Dam 18654 with and without superior oil gave good control.

Triforine gave good control on Clapp Favorite and fair control on Flemish Beauty but caused some fruit injury to the latter cultivar.

Strawberry diseases. The incidence of *Gnomonia fructicola* (Arn.) Fall was second only to that of *Botrytis cinerea* Pers.; both are parasites of calyxes of mature strawberry fruit. Dry necrotic calyxes on sound mature fruit often resulted from infection by *G. fructicola*. The stem-end fruit rot phase of *G. fructicola* is not prevalent on the cultivars grown in Nova Scotia. The weak parasite *Pezizella oenotherae* (Cke. & Ell.) Sacc. and the saprophytic *Alternaria* and *Penicillium* fungi colonized many calyxes, primarily as secondary invaders.

Benomyl, thiophanate-methyl, and captan were tested in a 2-yr trial for ability to control gray mold fruit rot caused by *Botrytis cinerea* on the strawberry cultivars Cavalier and Redcoat. All treatments increased mean marketable yields, and there was little difference among fungicides in the control of fruit rot. Maximum biological effectiveness of benomyl and thiophanate-methyl was attained with 1.68 kg/ha and 2.35 kg/ha, respectively, applied in three sprays.

Diseases of other crops. Postharvest treatment of washed carrots with benomyl- or thiabendazole-type fungicides gave significantly better control of storage decay than did Dovicide A (Dow Chemical). Gray mold and crater rots were the dominant types of decay.

Insect Pests

Apple maggot. Two and three cover sprays of azinphos-methyl at 0.2 kg/hl (0.25 lb/100 gal), with or without an attractant, were applied, but did not provide acceptable economic control of the apple maggot. The amount of fruit injury in the baited and unbaited spray plots was 9.6 and 5.1%, respectively, in 1972 and 6.0 and 5.7% in 1973. Injury in excess of 4% is unacceptable for domestic use, except for juice making, and no injury is tolerated for export markets.

In the test orchard, adults were active from July 17 to September 11, 1973, as determined by trapping. Gravid females were captured 3 days after each cover spray, which indicated a very short protective period and suggested that the dosage did not provide sufficient residues to persist over the 10-day interval between applications. Periodic capture for 35 days after the last

application* also indicated the need for additional cover sprays. More frequent low-dosage applications of azinphos-methyl could provide effective control of the apple maggot but would also destroy beneficial fauna, and the cost of the additional sprays would not be economical.

Four insect-developmental inhibitors were tested on various stages of the apple maggot. ZR515 (Zoecon Corp.) was the most effective compound, completely inhibiting adult development from larvae and pupae treated at concentrations of 10 μ g/20 cm². Larvae were more susceptible than pupae. Sensitivity declined as pupae aged. Dissection of puparia showed a pupal-adult intermediate, usually with some adult characteristics in the thoracic region. ZR512 (Zoecon Corp.) inhibited adult development from larvae or pupae exposed to concentrations of 1.0 mg/20 cm², whereas R20458 (Zoecon Corp.) inhibited adult development at concentrations of 10 mg/20 cm². RO 20-3600 (Zoecon Corp.) inhibited adult development from larvae exposed to concentrations of 10 mg/20 cm². ZR515 and ZR512 applied to fruit had little effect on larval development, but numbers of adults emerging from pupae from treated fruit were reduced. Adults from all tests produced viable eggs in the following generation.

Mean lethal doses (LD₅₀) in nanograms per fly were established for dimethoate, azinphos-methyl, phosmet, and phosalone by topical application of insecticides to the dorsum of the thorax of laboratory-reared adult apple maggots. The LD₅₀ for females treated with dimethoate was 2.4 ng, phosmet 11.2 ng, azinphos-methyl 12.1 ng, and phosalone 25.9 ng. Males were more susceptible than females.

Twenty other candidate pesticides were tested but none was as toxic as dimethoate. Eleven were about as toxic as azinphos-methyl. Diazinon and methyl parathion were the most toxic of these. Field-collected flies and strains from Vermont and Quebec were not significantly different in susceptibility from laboratory-reared flies. On a dry weight basis, the blueberry maggot and the apple maggot were almost identically susceptible to dimethoate.

Apple rust mite. The apple rust mite was active on apple leaves from late May until early August and passed through three

generations as indicated by the peak numbers of eggs. This species overwinters as deutogynes under bud scales and crevices in the bark. They laid eggs during the latter part of May. From these eggs the first-generation primaries were produced, followed by a second generation in the latter part of June. Eggs laid by the second-generation primaries produced the overwintering deutogynes. Injury to the leaves, mainly bronzing to the ventral surfaces, became noticeable early in July. The numbers of apple rust mite varied among cultivars within orchards. The differences were not consistent among orchards.

Wireworms and associated fauna. Granular formulations of the insecticides propoxur, fensulfothion, trichloronat, and Bayer 38156 (Chemagro) were applied in June to grassland at 2.2 kg ai/ha without subsequent cultivation. Trichloronat most reduced the numbers of wireworm, *Agriotes obscurus* (L.), and had the least effect on earthworms, *Allobophora tuberculata* Eisen. Propoxur and Bay 38156 reduced earthworm numbers. Collembola-Arthropleona increased in plots treated with fensulfothion and decreased in those treated with trichloronat and Bay 38156. Collembola-Symphyleona decreased in plots treated with fensulfothion, trichloronat, and Bay 38156. Mites increased in plots treated with propoxur and Bay 38156.

Strawberry weevil. Treatments of furadan, vydate, and malathion gave good control of strawberry weevil. Damage after each treatment was assessed by counting the number of blossoms that had been cut off.

PESTICIDE RESIDUES

Chlorfenvinphos. Application of chlorfenvinphos (Birlane, Shell Canada Ltd.; Supona, Shell Canada Ltd.; diethyl 1-(2,4-dichlorophenyl)-2-chlorovinyl phosphate; SD 7859; GC 4072) broadcast on field plots at 5.6 kg ai/ha (Birlane 100 at 56 kg/ha) 4 days before seeding resulted in traces of the parent compound in beets, potatoes, carrots, parsnips, and rutabagas at harvest. The α -isomer was found in all crops, except beets, at ~ 0.01 ppm. The β -isomer was found in all crops; carrots and parsnips contained 0.09 and 0.06 ppm, respectively.

Chlorfenvinphos residue concentrations in treated soil declined $\sim 73\%$ during the 23-wk

growing season after pesticide application, but trace residues could still be detected in the soil 4 yr later.

Endosulfan. When technical endosulfan was incorporated into soil at 6.7 kg ai/ha, studies showed that α -endosulfan decomposed fairly rapidly (50% reduction in ~ 60 days). Equivalent amounts of endosulfan sulfate, which appeared to be stable in soil, were formed simultaneously. β -Endosulfan disappeared slowly ($\sim 50\%$ reduction in 800 days). Endosulfan residues that were absorbed directly from the soil by potato tubers during the season in which the pesticide was applied at 6.7 kg/ha were measured. In the peel endosulfan sulfate was found at 0.3 ppm, β -endosulfan at 0.06 ppm, and α -endosulfan at 0.01 ppm; in the pulp endosulfan sulfate concentration was 0.03 ppm. Eight foliar sprays, each applied at the rate of 0.6 kg/ha, resulted in residues of 0.01 ppm endosulfan sulfate in peel and pulp.

Fensulfothion. Fensulfothion degraded rapidly in a sandy loam soil to the moderately persistent metabolite fensulfothion sulfone. Traces of fensulfothion sulfone were found in rutabagas grown on fensulfothion-treated field plots but were confined, for the most part, to the peel. Sulfone was detected in carrots at 0.10 ppm on a fresh weight basis. Fensulfothion sulfone persisted in frozen carrots during a storage period of 4 yr.

Simazine. When simazine at 4.48 kg ai/ha was incorporated with soil to a depth of 15 cm, 53, 40, and 18% were detected at 18, 63, and 161 days, respectively, after which there was a gradual decrease to 1.5% at 690 days.

A year after application the soil contained 0.18 ppm simazine. When crops were grown in this soil, no residues were detected in corn, oats, or beans. The latter two crops, however, were injured, and Swiss chard did not grow. There was slight toxicity to oats planted 2 yr after application, when simazine concentration in the soil had decreased to 0.03 ppm.

STORAGE

Estimation of gases in packaged vegetables. A 5-min evacuation technique was used to collect O₂, CO₂, ethanol, and ethylene from potato tubers surface-treated with substances inhibiting normal respiratory exchange. The method utilized the purging effect of steam

and the vacuum produced by its condensation.

Superficial scald in cold-stored apples. In 1972, the incidence of superficial scald in McIntosh apples was increased from 8.9 to 15.4% by fumigation with ethylene dibromide, whereas scald was reduced from 48.9 to 5.5% in fumigated Delicious apples. Ethylene dibromide must be tested because it is effective in killing overwintering European red mite eggs. Some countries have embargos on apples that might bear this pest.

Ripening of apples in controlled-atmosphere storage. Low or high ethylene (C_2H_4) levels and medium or high relative humidity have been found to influence the ripening of apples in controlled-atmosphere storage.

Low levels of atmospheric C_2H_4 (< 10 ppm) accompanied by low humidity (65%) during storage caused increased C_2H_4 production in the apple. When combined with high relative humidity (92–96%), low atmospheric C_2H_4 caused high carbon dioxide (CO_2) production and firmer apples. High C_2H_4 levels (> 500 ppm) in the storage atmosphere accompanied by either high or low humidity caused increased production of acetaldehyde, ethyl alcohol, and ethyl butyrate in the apple. Core flush (brown discoloration of the core) was inhibited more by a combination of low levels of atmospheric C_2H_4 and high relative humidity than by any other possible combination of these two variables.

High relative humidity had no effect on firmness but lowered the malic acid content, greatly increased the intensity of core flush, and increased the production of low molecular weight volatile compounds.

Low levels of atmospheric C_2H_4 helped maintain firmness of the apple fruit in controlled-atmosphere storage and slowed down the rate of senescence, which is evidenced by increased production of acetaldehyde and ethyl alcohol in the apple and the appearance of core flush.

Modified-atmosphere storage of pears. Clapp Favorite, Bartlett, and other named varieties of pears have been successfully stored in a self-generated (modified) atmosphere in 1-mil sealed polyethylene bags. A standard 0.9-kg (2-lb) sample of pears was placed in a nonperforated sac and the opening was hermetically heat-sealed. The respiration of the pears and the diffusion of

gases through the polyethylene sac set up a beneficial atmosphere of approximately 3% CO_2 and 7% O_2 when the storage temperature was -1.1 to $0^\circ C$ (30 to $32^\circ F$).

Alternaria disease of stored pears. *Alternaria alternata* (Fr.) Keissler seriously affected the stored cultivar Clapp Favorite during the 1972–73 and 1973–74 seasons. This is the first time this disease has been reported on pears in Canada. The five cultivars Cayuga, Ewart, Aurora, Conference, and Bartlett also had a light incidence of *A. alternata* during both storage seasons. Controlled-atmosphere storage showed some promise for control of *A. alternata*.

FOOD TECHNOLOGY

Development of a fluidized-bed freezer and dryer. Plastic beds of 30.4 or 45.7 cm diam were developed for freezing or drying 5- or 15-kg batches of particulate food products. Fluidization velocities of up to 243 m/min can be reached with either bed.

The freezer air temperature is controlled with the hot gas bypass load control on the two-stage condensing unit. Temperature control is within $\pm 0.88^\circ C$ throughout the range $-17.8^\circ C$ to $-40^\circ C$. A 15-kg sample of diced potatoes was taken from $15.5^\circ C$ to $-23.5^\circ C$ in 7.0 min, and a 5-kg sample, from $12.8^\circ C$ to $-23.5^\circ C$ in 3.5 min. Similarly, 3.0 min and 6.2 min were required to freeze 5-kg and 15-kg samples of diced apples.

The dryer air is steam heated to temperatures of up to $127^\circ C$; temperatures are controlled within $\pm 2^\circ C$ above $64^\circ C$ by a pneumatic cam programmer. Times required to dry 9.6-mm cubes of diced potatoes or apples to 10% of original moisture were in the range 1.5–3.5 h, depending on test conditions.

Cranberry juice concentration by reverse osmosis. Reverse osmosis produced a good-quality concentrate of 20–23% soluble solids from cranberry juice, with little loss of aroma, flavor, or color. When reconstituted as cranberry cocktail, concentrate prepared by this process tended to be preferred over concentrate produced by a climbing-film evaporative process, although no significant differences were observed. Energy consumption required to achieve similar levels of concentration was much lower in the case of reverse osmosis than in the case of a simple

evaporative process. Slight loss of acidity during the reverse osmosis process could offset energy cost savings by lowering the final yield when the product is reconstituted as cranberry cocktail. This procedure, however, presents the processor with a low-volume room-temperature alternative to large-volume freezer storage.

ANIMAL SCIENCE

Cattle

Calves from a Jersey \times Shorthorn cross were 5 kg lighter at birth than calves from a Brown Swiss \times Shorthorn cross. The average difference in weaning weight was about 5 kg for the first 3 yr, but was 20 kg for the 4th yr. The calves were weaned in early October.

Calculations based on feed consumption showed that it cost 2.93 cents a head per day less to maintain the Jersey \times Shorthorn cross. This represents a saving of about \$10.70 per cow per year. The cost of feed per tonne was: hay, \$28.60; corn silage, \$24.09; grass silage, \$26.84; and barley, \$110.00.

Calves from this experiment were fed to market weight at Fredericton, N.B. The cost per unit of gain was less for the steers from the Brown Swiss \times Shorthorn cross than for those from the Jersey \times Shorthorn cross. All carcasses were graded in the A category.

The data indicated that the Jersey \times Shorthorn cow has an economic advantage over the Brown Swiss \times Shorthorn cow until the calf is weaned, but this advantage is overcome by more efficient gains made by calves from the Brown Swiss \times Shorthorn cows during feedlot feeding.

Poultry

Meat stocks. An experiment was conducted to estimate the effects of varying the time interval between hatching and placement in the rearing house on mortality, carcass quality, feed conversion, and body weights of chickens. The time intervals studied were 0, 7, 24, and 48 h, under two programs of intermittent lighting. When birds that had spent the same amount of time in the rearing house were weighed, no significant difference in body weight was observed among any of the groups.

All chicks were exposed to continuous light to 7 days of age. Two experimental groups receiving continuous cycles of either 2 h of light and 4 h of darkness or 4 h of light and 2

h of darkness from 7 to 56 days of age were then compared with a control group that received continuous light to 56 days of age. There was no difference in performance except that the group on cycles of 2 h of light and 4 h of darkness exhibited better feed conversion than did the other experimental group.

A natural outbreak of infectious bursal disease occurred in an experimental broiler flock being reared on three starter diets containing 18.8, 21.6, and 24.0% protein. Groups fed the highest protein starter exhibited significantly higher mortality and had larger numbers of stunted birds.

Egg production stocks. Approximately 7000 Single-Comb White Leghorn (SCWL) birds were used to study the effects of the three following light treatments: a gradually increasing photoperiod during rearing; a modified photoperiod natural for Northern Hemisphere spring-hatched birds, which was decreased during the latter part of rearing; and a constant 14-h photoperiod from hatching to the end of rearing. Restricted feeding during the rearing period was also compared with full-feeding. Five commercial egg-production genotypes were used in each of these experiments.

Increasing the photoperiod during the rearing period was detrimental to general performance, and the return over costs was reduced when compared with that for the constant 14-h photoperiod treatment.

The results of a comparison between the 14-h constant photoperiod treatment and the modified natural photoperiod treatment that was decreased toward the end of rearing were not conclusive. The latter treatment, however, appeared to be somewhat superior to the constant 14-h photoperiod treatment.

Although the birds on restricted feeding showed higher returns on income over feed costs than did full-fed birds, the difference was not significant. The effect was not considered important enough under conditions of this experiment to offset the extra cost of imposing feed restriction. However, in an environment in which the photoperiod cannot be controlled, restricted feeding may be used to offset disadvantages associated with an adverse day length.

There was some evidence that indicated that interactions between genotype and photoperiod may be important.

It was concluded that in windowless houses, photoperiodism can be used effectively to achieve optimum performance among SCWL egg-production genotypes without using a rearing-period feed restriction program.

Sheep

Pregnancy diagnosis in the ewe. An echosounding device based on the Doppler principle was successfully used to determine pregnancy in ewes. The device is 98% accurate in detecting fetal sounds 60–90 days after conception and offers sheep men a means of detecting pregnancy long before it may otherwise be obvious.

Protein levels in creep feed for lambs. Lambs weaned from the ewe at 1 day of age and reared on cold liquid milk replacer for 24 days were fed rations formulated to contain 15, 20, and 25% crude protein from 24 to 70 days of age. The lambs on the 15% crude protein ration had a lower average daily gain than the lambs on the 20 and 25% rations. A ration containing 20% protein appeared to be adequate for the growth of early weaned lambs.

Effect of age and season on feed efficiency of lambs. The growth and feed efficiency of lambs born early (January–February) and late (April–May) were measured. Lambs were put on feeding at 70 ± 3 days of age and fed until they reached a live market weight of 40 kg. Late lambs utilized feed more efficiently than early lambs. Late lambs required about 5 kg less feed per kilogram of body gain than did the early lambs. There is no explanation for this difference, but early

lambs are subjected to more cold stress than late lambs.

Soil fungal toxins and lamb growth. Soil and herbage fungal spores had no effect on lamb growth in a pasture-grazing trial. Lambs were grazed on a pasture sprayed with thiabendazole at 560 g/ha and on an untreated pasture. Soil fungal spore counts exhibited considerable weekly variation and were highest in late June. Thiabendazole treatment was moderately effective in reducing spore counts. Weight gains were higher for the lambs on the treated pasture, but differences were not significant. There was no difference in the rumen fatty acid levels between the lambs on the two pastures. Rumen bacteria counts were similar for both groups. There were no significant differences over the growing season in the criteria measured.

Out-of-season breeding of ewes. There appears to be real potential for developing out-of-season breeding in sheep, adequate for the maintenance of year-round lambing for the well-managed flock. Five years of work with a Dorset \times Shropshire cross ewe flock gave promising results in out-of-season breeding. Up to 70% of ewes exposed to rams from March to May gave birth to lambs. These sheep had previously been bred in early fall to lamb in January. Rams were put in with the flock immediately after lambing in January. Most of the breeding activity took place during April. The results of this work are significant because no artificial stimulants such as light control or hormones were used. These sheep showed good breeding activity from early August to late January, to afford the flock owner a long breeding season. Considerable breeding activity in the early spring is also anticipated.

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Research Station

Fredericton, New Brunswick

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R. H. E. BRADLEY, B.Sc., Ph.D., D.Sc.	Aphid-borne viruses
M. C. CLARK, B.Sc., Ph.D.	Biochemistry of disease resistance
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G. C. C. TAI, B.Sc., M.Sc., Ph.D.	Quantitative genetics
T. R. TARN, B.Sc., Ph.D.	Cytogenetics
G. W. WOOD, B.Sc., M.A.	Insect control, small fruits

Departure

M. LANTAGNE, B.S.A., M.Sc.	Soil erosion
Resigned November 1974	

VISITING SCIENTISTS

P. S. HARRIS, B.Sc., M.Sc.	Potato viruses
On transfer of work from Department of Agriculture and Fisheries for Scotland	
<i>National Research Council postdoctorate fellows</i>	
J. R. SEOANE, B.Sc., M.Sc., Ph.D.	Ruminant nutrition
H. R. SHARMA, B.Sc., Ph.D.	Ruminant nutrition

¹On transfer of work at Michigan State University, East Lansing, Mich., USA, until August 1974.

²On transfer of work at National Research Council, Ottawa, Ont. until July 1975.

INTRODUCTION

The Research Station at Fredericton is the Canadian center for research on the potato crop. Emphasis is placed on breeding and genetics, pest management, soil and crop management, and harvesting and storage engineering. The Station is also the Atlantic center for research on animal nutrition, for studies on harvesting, storage, and utilization of cereal and forage crops for livestock feeding, and for environmental quality studies relating to the impact of nutrients and pesticides on water quality. The Station collaborates with other Branch establishments in evaluating new cultivars and selected management practices for New Brunswick.

Developments of interest during the year included the closing of the Potato Breeding Substation at Alma, after 29 years of operation. Construction of new facilities continued on a 340-ha (850-acre) site at Benton Ridge, 80 km (50 miles) north of Fredericton; the new Substation will be fully operational in 1975.

This report presents a summary of significant research activities during 1974. Additional information may be obtained by writing to Research Station, Research Branch, Agriculture Canada, Box 280, Fredericton, N.B. E3B 4Z7.

G. M. Weaver
Director

LIVESTOCK FEEDS AND ANIMAL NUTRITION

Frost Heaving of Alfalfa

A high degree of correlation was reported previously between the loss of alfalfa by frost heaving and the moisture equivalent of the soil. The widespread loss of alfalfa in the Atlantic region during the winter of 1973-74 confirmed earlier observations that loss by heaving becomes more severe as the soil moisture equivalent increases. The data also indicated a relationship between winterkilling per se and moisture equivalent. The determination of moisture equivalent, a fairly simple laboratory procedure, is a useful means of aiding producers in selection of sites for alfalfa production.

Fababean Yield Trials

High prices for protein have stimulated interest in the production of high-protein crops, including fababeans. In the past 3 yr yields of the licensed cultivars Erfordia, Diana, and Ackerperle averaged 3239, 2747, and 2467 kg/ha in plot trials, and approximately 1800 kg/ha in field-scale plantings.

Silage from Fababeans, Peas, or Sunflowers

Whole-plant silage from fababeans is a highly palatable feed for cattle and sheep. The feed was found to contain 20-25% dry

matter (DM) that was 62% digestible, and 16-18% protein, 67% digestible, if fababeans were harvested when the lower leaves were mature.

In preliminary comparisons of fababeans, peas, and sunflowers for silage, peas were the best crop, as they produced higher DM yields, higher DM digestibility, and higher daily consumption by sheep. They have a shorter growing season than the other crops, and must be harvested soon after they reach optimal maturity.

Supplements for Rations Containing Potatoes

When an adequate protein supplement was added to a basal ration of potatoes and corn silage, steer calves gained 18 kg (42%) more than calves on the basal ration in a 76-day experiment. When the ration was supplemented with urea the calves gained 9 kg more, but preformed protein was necessary in the supplement to obtain maximum gain and efficiency of feed conversion. The hypothesis on urea fermentation potential developed at Iowa State University was tested and found to be effective for predicting the amount of urea required in rations based on potatoes.

Improved Procedures for Analysis of Neutral-detergent Fiber in Cereal Grains

Neutral-detergent fiber (NDF) includes the total fibrous constituents of plant materials (cellulose, hemicellulose, and lignin). The filtration step in NDF analysis can be a source of error with cereal grains. A starch gel may form and block the filtering disk, which leads to overestimates of NDF.

When cereal grains were subjected to digestion by bacterial α -amylase at pH 7, the quantity of NDF (as a percentage of DM) was reduced by 15% in corn and by 6% in barley. This showed that the conventional NDF procedure did not completely remove the starch. Other treatments examined were predigestion by a fungal amylase at pH 5, and by pepsin at pH 1.8. The fungal amylase was less effective than the bacterial amylase. The treatments at pH 1.8 with or without pepsin gave equal NDF values, indicating that the conventional NDF contained little protein and some of the hemicellulose was hydrolyzed at pH 1.8. The bacterial α -amylase treatment is an inexpensive and simple modification that made filtration easier and provided a more accurate assay of the fiber content of cereal grains.

Ensiled Complete Feeds for Dairy Cows

When second-cut timothy (65% moisture) was ensiled, grain was added to a level of 40% of total DM to form a complete feed for dairy cows. This feed was compared with timothy silage fed in the conventional way (as silage ad lib. plus grain at 1.0 kg for each 3.0 kg of fat-corrected milk), to determine the effects of the two rations and feeding methods on feed intake, milk yield, and milk composition. Cows fed timothy silage in the conventional way consumed 2.9 kg more DM, produced 1.6 kg more fat-corrected milk daily, and gained less body weight than cows fed the complete feed during a 12-wk period. Milk composition and rumen volatile fatty acids were unaffected by the method of feeding. When the two rations were fed to sheep, digestibility of DM and energy was similar but protein digestibility was higher for the timothy silage. For cows in early lactation, a higher ratio of grain to forage must be used in complete feeds based on grass silage.

Milk Fat Depression in Dairy Cows

Dairy cows were offered 13.6 kg of concentrates in two physical forms, mash or pellets, and at three levels of hay intake, 4.5, 6.8, and 9.1 kg/cow daily, to determine the effect of physical form of the concentrate and level of fiber intake on milk composition. Cows fed the pelleted concentrate had significantly lower acetate and higher propionate levels in the rumen. Milk composition was not affected by the physical form of the concentrate or the level of hay intake.

Formaldehyde Treatment of Protein

A low level of formaldehyde was added to rapeseed meal or ground fababeans in rations fed to sheep. This reduced the breakdown of protein in the rumen and increased the amount of protein nitrogen that reached the abomasum. A higher level of formaldehyde (1.5 g/100 g of protein) was required to protect the highly soluble fababean protein than the rapeseed protein (1.0 g/100 g of protein).

Control of Abomasal Bloat in Lambs

The addition of 0.1% (v/w) of formalin (37% formaldehyde) to milk replacers containing 20% solids nearly eliminated abomasal bloat in lambs fed warm milk replacer to appetite twice daily. There was no adverse effect on the lambs' growth or their digestion of nutrients in the milk replacers. When formalin was added at 0.15%, some lambs decreased their intake of the milk replacer. Microorganisms in abomasal or rumen digesta produced markedly less gas when incubated in vitro with milk replacer containing formalin. The predominant gas-producing organism in lambs that became bloated was *Lactobacillus fermenti*. Gas production by this organism was not affected by the presence of fats or fatty acids in the milk replacer (tallow or low-erucic-acid rapeseed oil; mixture of 67% oleic and 16% stearic acids). Rather high levels of most antibiotics tested were required to reduce gas production by *L. fermenti*.

Milk Replacer Feeding Systems for Lambs

Two experiments were completed at the Experimental Farm, Nappan, to determine the effect on the performance of lambs when 0.05% formalin was added to a milk replacer containing 20% solids, and when their intake

of milk replacer was restricted. Lambs fed ad lib. formalin-treated milk replacer at 17°C from 1 day old to weaning at 28 days tended to grow faster and consume more than lambs fed refrigerated (5°C) milk replacer without formalin. Weight gains were 237 and 192 g/day. The same formalin-treated milk replacer was fed to lambs either ad lib. or restricted to 900 g/day after they reached 8 days of age. Weight gains to weaning at 28 days were 311 and 212 g/day, and gains to 10 wk 259 and 220 g/day. Intakes of DM from the milk replacer were 8.8 and 5.4 kg per lamb. These lambs did not suffer any abomasal bloating or other digestive disturbance.

POTATO BREEDING

Belleisle, a New Table Stock Cultivar

Fredericton seedling F58010 has been named Belleisle and released as a main-crop cultivar. It has excellent table quality and resists bruising. It is comparable to Kennebec in yield and matures in about the same time as Katahdin. Consumer acceptance trials conducted in Montreal and Toronto showed that Belleisle was highly acceptable as a table potato. The white color and the texture of the cooked tubers received highly favorable comments from Toronto markets. Approximately 1000 35-kg bags of Elite II and Elite III seed will be available for distribution in early 1975.

Benton Ridge Potato Breeding Substation

Modern facilities have been constructed on the 340-ha site at Benton Ridge, 80 km north of Fredericton, to accommodate the field requirements of the potato breeding project. The structure includes a greenhouse and laboratory as well as storage facilities for potatoes and machinery, which should improve the scale and scope of breeding activities conducted at this site. This new complex will replace the Substation at Alma, which was operational for 29 yr.

Computer Storage of Data on Potato Parentage

As an aid to the selection of parents, a computer program has been written to store information on all potato crosses from 1960 to 1973. For each indexed cross, presented according to parent, the system records the

cross number, year of first field trial, other parent, number and percentages of seedlings grown and selected during each of the successive stages of progeny testing (single-, 4-, 10-, and 100-hill trials), and the running percentages of seedlings selected at each stage compared with the total number of seedlings grown at the single-hill stage. Summary results are also given on all other crosses in which a parent was involved. A general description of the characteristics of each cross, taken at the single-hill stage, is presented separately. The Selection Record now contains information on 346 parents and 1031 crosses.

Genotype-Environment Interactions of Potato Varieties

A method was developed for analyzing the genotype-environment interactions of potato varieties. It is based on the concept that the three yield components of a potato genotype, number of stems per unit area (X), number of tubers per stem (Y), and average tuber weight (Z), are determined at sequential stages in the development of plants. Yield (W) is a product of the components, that is $W = XYZ$. The assumption is made that environmental resources can be separated into independent groups (R_1 , R_2 , and R_3), each supporting the development of a component trait. The interacting effects can then be broken down into three multiplicative terms, each with a genotypic and an environmental component. The three genotypic components each represent the efficiency with which a genotype uses the environmental resources during the successive stages of plant development toward the formation of final yield.

Tuberosum-Andigena Potato Hybrids

One of the most significant short-term contributions anticipated from hybrids of Tuberosum (T) and Andigena (A) is an increase in yield. In single-hill populations, TA and AT hybrids outyielded TT seedlings by 31% and 12% in 2 consecutive yr. In the 2nd yr, when the Tuberosum seedlings yielded better, nine of the ten hybrid progenies gave yields greater than the mean yield of the TT population, whereas none of the five TT progenies had a mean yield equal to the mean of either hybrid population. The best hybrid outyielded Kennebec by 13% under normal crop management practices.

Tuberosum-Andigena F_1 hybrids differ in plant type from present varieties in that the hybrids have more stems and tubers per hill, and tuber size is small. Earlier work has shown that an important component of the heterosis of such hybrids is the multiplicative interaction of large tuber size from the Tuberosum parent and high set from the Andigena parent. This being so, high sets will be a characteristic of such high-yielding hybrid varieties when they are released commercially. Because all primitive cultivars share similar characteristics of plant type, whether they belong to the group Andigena or to *Solanum phureja*, management practices may have to be modified in breeding programs that use these germ-plasm resources.

Diploid Breeding

A stockpile is being established to contain haploids from many well-adapted tetraploid varieties and breeding stocks of diverse genetic origin. Several "superior seedparents" have tentatively been identified (these are tetraploid clones that produce a fairly high frequency of parthenogenetic haploids). The haploids are being evaluated for many economically important traits. Several introductions of cultivated diploid potatoes (groups Phureja and Stenotomum) are being screened for adaptation to the Canadian environment.

Aphid Resistance in *Solanum*

More than 1500 seedlings from the F_1 generation of crosses between survivors of previous screenings of diploid species of *Solanum* were infested with aphids. Their response was noted, and 263 of them were reserved for electronic examination. Among the controls, F_1 generation of Katahdin selfed, 830 seedlings were screened and one was retained. From the subsequent electronic read-out eight selections were rated resistant and 21 sufficiently unusual to merit further examination. These 29 will be regrown. The material is mainly from bulk pollen crosses of *S. canasense* and *S. sanctae-rosae*.

Between June and September, 25 new species accessions from the Potato Introduction Station at Sturgeon Bay were exposed in the field to populations of the four aphid species that infest potatoes. They included *Solanum multidissectum* (1 clone); *S. canasense* (5); *S. brachistotrichum* (2); *S.*

sanctae-rosae (4); *S. cardiophyllum* (3); *S. stoloniferum* (6); and *S. polyadenium* (4). Some clones of *S. multidissectum*, *S. brachistotrichum*, *S. polyadenium*, and *S. canasense* showed good resistance to the aphids. Others were almost as susceptible as the controls (Katahdin).

Twenty-three cultivars of *S. tuberosum*, named varieties and advanced Fredericton seedlings, were exposed to aphids in the field, as were the species. No selection was as resistant as the species, although F65071 was almost as resistant and F51013 and F65113 were highly tolerant to field populations of aphids.

Resistance to Potato Virus Y

As a result of tests during the past 5 yr, 51 Fredericton seedlings have been rated highly resistant to potato virus Y (PVY). Another 40 F-seedlings have been rated moderately resistant, and 78 susceptible. Most of this resistance can be traced to extensive use of Katahdin and USDA seedling 46952 in the early years of the breeding program, followed by continued use of several resistant local parents (F45019, F47024). Twenty-five commercial varieties have also been found resistant to PVY.

Resistance to Potato Leaf Roll Virus

Resistance to the potato leaf roll virus (PLRV) has been confirmed in the U.S. cultivars Penobscot and Abnaki, as well as moderate resistance in Katahdin. The Dutch cultivar Dorita and Fredericton seedlings F6441 and F59103 also appear to be resistant. Several other Fredericton cultivars and seedlings have been confirmed as moderately resistant.

POTATO PATHOLOGY

Computer Forecasting for Late Blight Control

The efficiency of a computer program for forecasting the time to apply sprays for late blight control was evaluated in the New Brunswick potato industry. Data on temperature, humidity, and rainfall from three test areas were fed into the computer twice weekly as a means of forecasting spray requirements. Satisfactory control of blight was obtained with an average of two fewer sprays than normally recommended.

Fingerprints of Multiple Forms of Potato Spindle Tuber Metavirus

Potato spindle tuber metavirus (PSTM) was extracted from infected plants of *Scopolia sinensis* Hemsl. with phenol. Total nucleic acid was precipitated with cetyltrimethyl ammonium bromide, and metavirus RNA was purified by extraction with lithium chloride and with isopropyl alcohol, and by polyacrylamide gel electrophoresis. Two distinct peaks of infectivity were found by 10% gel electrophoresis. The slow-moving peak (I) was further separated into two components by high-pressure liquid chromatography on glycoPhase G columns, and the fast-moving infectious peak (II) was recovered after gel electrophoresis. Both infectious forms were digested with pancreatic ribonuclease, treated with bacterial alkaline phosphatase, and labeled with γ -[32 P]ATP-poly-nucleotide kinase according to Richardson's procedure. After the reaction mixture was treated with glucose and hexokinase, the digests were separated by electrophoresis on cellulose acetate at pH 3.5 and by the homochromatographic procedure of Sanger. The two infectious PSTM forms gave different fingerprint patterns, indicating their dissimilarity (work done in cooperation with Dr. S. A. Narang, National Research Council, Ottawa).

Effects of Metabolic Inhibitors on Spore Germination in *Phytophthora infestans*

The influence of some nucleic acid derivatives, their structural analogues, and several metabolic inhibitors on spore germination in *Phytophthora infestans* (Mont.) de Bary was investigated. Adenine, hypoxanthine, and the riboside of *N*⁶-dimethyl adenine stimulated indirect germination in race 1,2,3,4, but these compounds had no effect on germination of the less virulent race 1,4.

The enhancement of zoospore production in race 1,2,3,4 contrasted sharply with the decline in rate of zoospore formation when sporangia were incubated with the purine analogue benzimidazole. Except for its apparent reversibility, this inhibition was identical to that observed when sporangia were treated with low concentrations of the respiratory inhibitors sodium azide and 2,4-dinitrophenol.

The most striking effect on spore development occurred when spores were incubated with actinomycin D. This antibiotic almost

completely inhibited growth and development of germ tubes, but only slightly affected the germination process per se. At first it was concluded that this response could be explained in part by a difference in the permeability of the sporangium and the zoospore with respect to the uptake of actinomycin D. However, a very similar pattern of inhibition was produced by 5-fluorouracil, which suggested that such a difference in permeability may not be the exclusive factor in the differential behavior of the sporangium and zoospore.

Tests for Symptomless Strains of Leaf Roll Virus

On the basis of reports from the Research Station at Vancouver, symptomless strains of leaf roll virus (PLRV) may be quite common in North American potatoes. However, tests of about 800 seed potatoes from various parts of New Brunswick have failed to reveal any infected with symptomless PLRV. The test methods were the same as those used at Vancouver. Each potato was infested soon after emergence with young nymphs of *Myzus persicae* (Sulz.), which fed for several days. Then the nymphs were placed on healthy young seedlings of *Physalis floridana* Rydb., which develops diagnostic symptoms when infected with any of the known strains of PLRV. After the test seedlings were freed from aphids they were maintained for 4-6 wk in a growth cabinet at 28°C. The potato plants being tested were also maintained in a glasshouse for 10-15 wk and observed for symptoms of leaf roll.

Most of the tubers tested were Kennebec, because that variety was the one most often infected with symptomless PLRV at Vancouver. About 1% of the 800 tubers tested were infected with PLRV, but all of these produced plants with unmistakable symptoms of leaf roll. Plants from some of the remaining tubers developed mild to moderate rolling of some leaves. Repeated tests of these suspect plants did not reveal any infected with PLRV.

POTATO ENTOMOLOGY

Pest Management

The work in cooperation with the New Brunswick Department of Agriculture and Rural Development has been intensified. An

aphid alert program started in which greenhouse and storage areas in the potato production area were examined early in the season. Appropriate control measures were instituted as required. Insects (aphids, Colorado potato beetle, and flea beetles) were counted weekly in potato fields and the counts were used with pertinent meteorological data to project hazardous levels of insect populations and timely implementation of controls. To evaluate the effectiveness of this approach, the same data were used as a basis for insect control in research plots at three locations within the potato production area.

Aphid populations were generally low. *Aphis nasturtii* Kaltenbach was the most abundant species, followed by *Macrosiphum euphorbiae* (Thomas); both appeared by the end of June. *M. persicae* was not found until the 3rd wk of July. In plots that received a systemic insecticide, the first two species were not encountered before August 21 and the last not before August 14.

Aphid populations and the time and effectiveness of topkilling were closely examined. *M. persicae* was found in traps again in 1974 after topkilling. The lower leaves of many plants remained green and were subject to aphid infestation. Thorough topkilling is important to prevent the spread of disease in early September.

POTATO PHYSIOLOGY, CROP AND SOIL MANAGEMENT

Growth Analysis

The influence of stem number on the growth and development of the potato was studied by comparing one-stem, two-stem, and four-stem plants of Kennebec. In stands of each plant type, the rate of DM production over the season increased with stem number; weekly DM production was 90, 105, and 116 g/m². The three stem types used a similar proportion of DM production for new leaf growth up to the time tubers began to form, but afterwards the multiple-stem plants used a smaller proportion for new leaf growth than did single-stem types. Numbers and dry weights of tubers were consistently superior in two- and four-stem plants.

In terms of plant efficiency during early growth, the relative growth rate of one-stem plants was 40% per wk and that of two- and four-stem types was 38% per wk. When

tubers were filling out this trend was reversed, 10% per wk going to tuber growth in single-stem plants and 12% per wk in multiple-stem types. The rate of leaf area expansion was greatest in one-stem plants; the rates were 24, 21, and 20% per wk for one-, two-, and four-stem plants.

The net assimilation rate was greatest in multiple-stem types, with a weekly rate of DM production of 38 g/m² compared with 30 g/m² in one-stem plants. The main factors that determined the net photosynthetic production of the plants were the sink demands expressed by the processes of tuber formation and development. Size and arrangement of the canopy appeared to have a smaller effect.

Transplanted and Sprouted Netted Gem Potatoes

Yields of Netted Gem potato transplants set out on three dates and yields from sprouted whole small seed and sprouted cut seed were compared with yields from unsprouted seed. Transplants, 10–12 cm in height, were set out in the field at the time seed was planted and 1 and 2 wk later. Plants from sprouted cut seed produced 7% more marketable tubers than plants from unsprouted cut seed. When sprouted whole small seed was used, marketable yield was 4% lower although total yield was 10% higher. Transplants set 2 wk after seed planting gave 17% higher total yield and 18% higher marketable yield. Transplants set 1 wk after seed planting produced 26% higher total yield and 33% higher marketable yield than yields from unsprouted seed. The early transplants, set at the time seed was planted, gave 28% higher total and marketable yields.

Mulching Netted Gem Potatoes

The effects of mulching on the growth and yield of Netted Gem potatoes were studied by comparing results from soils with mulches of clear plastic, black plastic, and plastic-coated black paper with results from tilled and untilled soil without a mulch. Thermocouples were placed at seed depth in each plot and soil temperatures were recorded throughout the season. Three weeks after planting, average emergence of plants was 37% with clear plastic, 31% with plastic-coated black paper, 25% with black plastic, and 6% from unmulched soil.

Maximum and minimum daily soil temperatures during the first 6 wk were markedly higher under clear plastic than in unmulched soil. Maximum temperatures under black plastic were slightly higher for the same period but temperatures under plastic-coated black paper varied little from those in unmulched soil. Once a leaf canopy was established soil temperatures varied little among treatments, but when the tops of plants senesced temperatures rose again under clear and black plastics.

No increase in yields resulted from mulching despite earlier emergence, and yields from plots with clear plastic were actually lower.

Potato Storage

The rate of moisture loss from Kennebec potatoes early in the storage period was experimentally determined by static salt solution techniques. The tubers were subjected to temperatures of 4.5, 16.6, and 28.3°C and a relative humidity range of 11.9–98.4%. The experimental data were fitted to a drying equation:

$$WT = C_1 (VPD)^{C_2(t)^{C_3}}$$

where WT = weight loss per unit of tuber (kg vapor/kg tuber), VPD = vapor pressure difference (mm Hg), t = time (h), and C_1 , C_2 , and C_3 were regression coefficients.

A simulation model of potato cooling was developed and experimentally verified by a comparison of predicted and experimental gradients of temperature in a 2.4-m column of potatoes. The total moisture loss from the column of potatoes was also compared with the calculated value. The experimental and predicted values agreed satisfactorily.

Soil Compaction

Assessment is being made of the influence of various physical properties of soils on potato yields in Carleton and Victoria counties, as indicated by data from 19 farms. In associated investigations, a simple correlation coefficient ($r = 0.69$) showed a relationship between the oxygen diffusion rate at the 25-cm depth when moisture was at field capacity, and the extent of soil compaction. Oxygen diffusion rate varied from 0.21 to 0.45 $\mu\text{g}/\text{cm}^2$ per min.

FRUIT CROPS

Forest Spraying and Blueberry Production

Fenitrothion, used for control of the spruce budworm, is highly toxic to bees. Blueberry growers have made claims for crop losses that they attribute to mortality of pollinators resulting from the forest spray operation. Alternative materials with a higher level of specificity have been tested for budworm control, and one of them, trichlorfon, has shown promising results in preliminary tests carried out by the Canadian Forestry Service. Trichlorfon is of particular interest to the blueberry industry because it is relatively nontoxic to bees. In a recent test, no effect on the activity of honey bees or native bees resulted when an adjacent forest block was sprayed with trichlorfon (Dylox 4L; Chemagro Corp.) at the rate of 0.46 kg active ingredient (ai)/ha. In another test a blueberry field was sprayed directly by aircraft with trichlorfon (Dylox 80 sp; Chemagro Corp.) soluble powder at 1.1 kg ai/ha, with no effect on pollinators. If current tests show trichlorfon to be effective for budworm control, it can provide a compatible alternative in areas adjacent to blueberry plantations.

Control of Blueberry Flea Beetle

Insect surveys detected a serious outbreak of the blueberry flea beetle, *Altica sylvia* Malloch, in New Brunswick. Trichlorfon (Dylox 80 sp) controlled larvae effectively in early June and did not cause significant mortality to pollinators. Azinphos-methyl applied in mid-July effectively controlled the adult stage of the blueberry maggot as well. Results indicate these compounds to be superior to carbaryl, which is recommended at present.

ENVIRONMENTAL QUALITY

Nutrient Concentration of Various Water Sources

Studies on the environmental effects of agricultural practices have been particularly concerned with the nutrient content of water discharge from streams. Associated studies started in 1973 have related to nutrient concentrations in tile drainage effluent and in domestic wells. Comparisons of concentrations in forest streams, agricultural streams,

tile drain effluent, and domestic wells have proved to be interesting. Levels of nitrate nitrogen were 0.6, 3.2, 4.0, and 7.0 ppm, respectively; phosphorus 3.0, 9.0, 10.0, and 10.0 ppb; and potassium 0.4, 1.2, 3.0, and 7.0 ppm. Differences between the levels were similar for calcium, magnesium, chloride, and sulfate. The relatively high levels of nitrate nitrogen and phosphorus encountered in a number of domestic wells are under investigation.

Ethylenethiourea Residues in Potatoes

Recently concern has been expressed about residues of ethylenethiourea (ETV), a metabolite of dithiocarbamate fungicides which are used extensively for late blight control. Tubers from potato plants treated with mancozeb at weekly intervals for 10 wk at rates up to 2 kg/ha were analyzed for ETU residues by thin-layer chromatography. Estimated concentrations ($6\text{--}10\ \mu\text{g}/100\ \text{g}$) are now being assessed by more highly quantitative methods of gas chromatography.

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Ferme expérimentale L'Assomption, Québec

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Physiologie

Pesticides

Génétique et amélioration
du tabac à cigare

Phytotechnie

SCIENTIFIQUE INVITÉ

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INTRODUCTION

Le but principal de cette Ferme est de poursuivre des recherches sur trois types de tabac, soit tabac à cigare, à cigarette et à pipe.

Pour la première fois cette année, le tabac à cigare a été séché dans des séchoirs en vrac et dans un séchoir à seulement une travée recouvert de plastique. L'objectif du travail en coopération avec le ministère de l'Agriculture du Québec, avec les manufacturiers de cigares et aussi avec la Coopérative des producteurs de tabac à cigare est d'introduire la mécanisation dans la production et le séchage du tabac à cigare.

Nos recherches sur la répression des vers gris du tabac ont été intensifiées par le travail du Dr G. McLeod de l'Institut de recherches de London. Le Dr McLeod travaillera chez nous pendant un an.

Cette publication représente un résumé des principaux résultats de recherches obtenus en 1974 à la Ferme expérimentale de L'Assomption. De plus amples détails se rapportant aux recherches en cours sont disponibles en adressant les demandes à la Ferme expérimentale, Agriculture Canada, C.P. 1070, L'Assomption, P.Q. J0K 1G0.

P. P. Lukosevicius
Directeur

TABAC

Tabac à cigare

Études génétiques. L'efficacité d'une méthode d'amélioration utilisée pour obtenir de nouvelles variétés par hybridation dépend de l'action et de l'interaction des gènes provenant des génotypes parents. Une expérience en vue de déterminer les différentes portions de la variance génétique dans le tabac à cigare a été complétée. Les résultats morphologiques et agronomiques obtenus démontrent que la plus grande partie de la variance génétique fut additive, ce qui corrobore la méthode d'amélioration utilisée jusqu'à présent à notre établissement pour obtenir de nouvelles lignées de tabac à cigare.

Séchage. La mécanisation de la récolte peut réduire les coûts élevés de la production du tabac à cigare. Le tabac récolté mécaniquement peut être amélioré pendant la période du séchage, si l'on utilise une méthode différente de celle dite conventionnelle. Les résultats obtenus d'une expérience pilote, utilisant du tabac à cigare récolté mécaniquement, indiquent que le tabac peut aussi bien être séché dans un séchoir en plastique à un niveau de pente que dans un séchoir conventionnel. De plus, le tabac à cigare ne demande qu'une dizaine de jours pour sécher dans un séchoir en vrac. Les feuilles détachées du plant séchent mieux dans ce séchoir que les plants entiers.

Test de dégustation. Comme les caractéristiques morphologiques, agronomiques et chimiques du tabac à cigare peuvent être affectées par les conditions climatiques durant sa croissance, on présuma que les qualités dégustatives des cigares le seraient parallèlement. Des cigares fabriqués avec du tabac de dix variétés et deux lignées hybrides expérimentées de 1967 à 1969 furent évalués par 250 fumeurs d'un jury de dégustation. Le classement des cultivars, établi d'après l'appréciation des dégustateurs, varia considérablement d'une année à l'autre, ce qui explique que des résultats d'évaluation basés sur 3 ans d'essais ne sont pas suffisants pour recommander la commercialisation d'une lignée de tabac à cigare.

Méthodes culturales. En 1974 nous avons modifié cette expérience. Elle se compose maintenant de trois distances de plantation, soit 30, 36 et 41 cm (12, 14 et 16 po), de trois stades d'écimage, soit début floraison, 25% floraison et 50% floraison et aussi de deux hauteurs d'écimage, soit haut et normal. Chaque parcelle est récoltée à un stade appelé maturité physiologique. Les résultats de cette année nous indiquent qu'une plantation à raison de 30 cm (12 po) entre les plants, avec un écimage haut au stade 25% floraison, nous donne le meilleur rendement. Pour la qualité et le revenu, c'est différent: une distance de 36 cm (14 po) combinée à un écimage au stade de 50% floraison sont le

plus favorables. Par contre, la hauteur d'écimage est la même que pour le rendement, soit écimage haut.

Tabac à cigarette

Évaluation des cultivars. En 1974 nous avons comparé la valeur agronomique de 14 cultivars. Sept cultivars ont surclassé le témoin Delhi 34. Au point de vue du rendement, Strain C-18 venait au premier rang. Trois cultivars seulement étaient supérieurs au témoin pour l'indice de qualité, Delhi 34 72-D 21-3F se classant le meilleur. En ce qui concerne le revenu brut à l'acre, six cultivars surpassèrent le témoin, Strain C-18 étant le premier. Le temps nécessaire pour parvenir à la floraison s'échelonne entre 66 jours (cinq cultivars) et 74 jours (Mutagenic 205).

L'effet de N, P et K sur le tabac. Commencé en 1973, ce projet comporte l'essai de quatre niveaux d'azote, quatre niveaux de phosphore, quatre niveaux de potasse et deux types de sol. Les résultats démontrent qu'on obtient les mêmes résultats sur un sol riche avec des applications de fertilisants inférieures à celles faites sur un sol pauvre. Les équations des fonctions de production nous indiquent que le rendement, la qualité et le revenu sont fonction de l'application d'azote et de potasse. Le phosphore pour sa part influence la maturité.

Répression des drageons du tabac. En 1974, six produits différents furent mis à l'essai afin de connaître leur pouvoir de répression sur les drageons du tabac. L'expérience comprenait aussi deux stades et deux méthodes d'application. Tous les produits ont assuré un bon contrôle des drageons. Une application des produits à la machine a diminué le rendement de 3.7%, l'indice de qualité de 1.0% et le revenu brut de 4.8%, en comparaison avec une application manuelle des produits.

Si l'on compare les temps d'application, nous constatons qu'une application avant écimage assure un meilleur contrôle des drageons qu'une application après écimage.

Distance et écimage. Cette année un nouveau projet a été mis sur pied portant sur l'étude de trois stades d'écimage (début bouton, début floraison et 25% floraison) ainsi que sur trois distances de plantation sur le rang (41, 51 et 61 cm — 16, 20 et 24 po) avec des rangs espacés de 122 cm (48 po).

Les données préliminaires accumulées jusqu'à présent ne permettent pas de certifier la prédominance d'un traitement sur un autre. Mais elles démontrent quand même des tendances favorables, pour le rendement, l'indice de qualité et le revenu brut, pour une plantation distancée de 41 cm (16 po) sur les rangs et 122 cm (48 po) entre les rangs. D'autre part, on obtient un meilleur rendement avec un stade d'écimage de début floraison, tandis qu'un meilleur indice de qualité et un meilleur revenu brut sont atteints par un écimage au stade début bouton.

Cette première année nous laisse entrevoir des résultats concrets dans le cas d'une plantation de 41 cm (16 po) sur le rang et d'un écimage au stade début bouton.

Fumigation d'automne par rapport à fumigation de printemps pour la lutte contre les nématodes. Trois nématocides fumigants, D-D (Shell Canada), Telone (Dow Chemical of Canada Ltd.), Vorlex (Nor-Am Agricultural Products Ltd.) appliqués soit l'automne précédant la transplantation à la volée, soit le printemps de la transplantation à la volée ou sur le rang, n'ont apporté qu'une légère augmentation du rendement et du revenu brut en comparaison avec le tabac non traité. Les nématocides appliqués en rang au printemps ont donné le plus de tabac.

Nématocides non fumigants. Les nématocides triazophos et Vydate (DuPont of Canada Ltd.) ont augmenté le rendement de 131 et 200 kg/ha (118 et 180 lb/ac) respectivement, tandis que carbofuran a porté le rendement à 54,4 kg/ha (49 lb/ac) en deçà des tabacs non traités. Les trois nématocides ont donné des qualités moindres, soit 4.4 cents de moins par kilogramme de tabac (2.0 cents/lb) pour carbofuran et Vydate, et 6.6 cents (3.0 cents/lb) pour triazophos.

Répression des mauvaises herbes. Combinés à deux sarclages mécaniques, les traitements herbicides ont donné des rendements de tabac supérieurs à ceux du tabac sarclé un même nombre de fois mais n'ayant reçu aucun herbicide. Par contre, lorsque les parcelles ont été tenues exemptes de toutes mauvaises herbes durant tout l'été à l'aide de deux sarclages mécaniques et à l'aide d'autant de sarclages manuels que requis par la pousse des mauvaises herbes, tous les herbicides ont abaissé le rendement en deçà des parcelles sans herbicide.

Répression des vers gris. Pour contrôler le ver gris blanc, *Euxoa scandens* (Riley), il faut recourir à deux applications soit de chlorpyrifos ou soit de leptophos avant la transplantation, la première application se faisant tôt au printemps et la seconde immédiatement avant la transplantation. Les applications ont été faites tant sur le seigle que sur le sol devant être planté en tabac. Les insecticides chlorpyrifos et leptophos appliqués avant la transplantation n'ont pas réussi à combattre efficacement le ver gris moissonneur *E. messoria* (Harr.). Leptophos en poudre soluble et N-2596 (Stauffer) appliqués en post-plantation à des intervalles de 15 jours ont

solutionné le problème. On n'a noté aucun signe de phytotoxicité avec l'un ou l'autre des deux insecticides.

Nous avons observé la présence de *E. scandens* dans toutes les régions du Québec où se cultive le tabac à cigarette.

Répression des taupins. L'identification des adultes de cet insecte révèle que l'espèce taupin commun *Melanotus fissilis* (Say) domine. L'insecticide granulé fonofos s'est avéré très efficace sans causer de dommage au tabac.

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Divers

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Station de recherches Lennoxville, Québec

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INTRODUCTION

La recherche à cette Station s'oriente vers les productions animales: bovins laitiers, bovins de boucherie, porcs et moutons, cette dernière en collaboration avec la Ferme expérimentale de La Pocatière. Elle porte également sur la production et l'utilisation des cultures herbagères, soit pâturage en été ou foin et ensilage en hiver.

Il convient de noter l'importance accrue que l'on accorde graduellement à la recherche en bovins laitiers, tant pour la production laitière que l'exploitation pour fin bouchère. D'autre part, on intensifie la recherche portant sur la survie de la luzerne à l'hiver, particulièrement l'effet physique de l'exhaussement du sol par le gel.

Ce rapport décrit sommairement les résultats de quelques expériences. Un compte-rendu plus détaillé de toute la recherche en cours est disponible en s'adressant à: Station de recherches, Agriculture Canada, Lennoxville, Québec, J1M 1Z3.

C. S. Bernard
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ZOOTECHNIE

Alimentation du veau au colostrum suri

On a entreposé, dans des barils en métal, suffisamment de colostrum pour nourrir 12 veaux durant 4 semaines au taux de 12% de leur poids vif. On a comparé leur performance à celle de veaux alimentés au lait entier, servi froid. Quatre des 12 veaux recevaient uniquement du colostrum suri, tandis que les huit autres recevaient un mélange de 75% de colostrum suri et 25% d'un lait de remplacement, reconstitué à 12% de matière sèche et servi à 43,3°C. Suite à la période expérimentale de 4 semaines, nous avons servi, à tous les veaux, du lait de remplacement contenant 30% de graisses durant 5 semaines de finition afin d'observer si le colostrum suri aurait un effet résiduel sur la croissance du veau.

Le gain de poids vif durant les 28 premiers jours a été de 0,41 kg par jour pour les veaux au colostrum suri, de 0,36 kg pour ceux au colostrum suri et lait de remplacement et de 0,54 kg pour ceux au lait entier. La digestibilité de la matière sèche était de 81.2%, 92.8% et 87.4% respectivement, pour le colostrum suri, le mélange et le lait entier. Le dosage de protéines (sur base de matière sèche) et de matière sèche était de 43.68% et 14.5% dans le colostrum suri, de 31.3% et 13.1% dans le mélange et de 21.9% et 11.4% dans le lait entier. Le colostrum suri contenait donc presque deux fois plus de protéines que le lait entier.

Durant les 5 semaines de finition, les veaux nourris au colostrum suri ont accusé un gain journalier moyen de 1,1 kg, ceux nourris au mélange un gain de 1,2 kg et les quatre

nourris au lait entier pour toute la période de l'expérience, un gain de 1,1 kg.

La performance des veaux nourris au colostrum suri se compare favorablement à celle des veaux nourris au lait entier ou au mélange de colostrum suri et de lait de remplacement.

Niveaux de protéines et de graisses dans les moulées d'engraissement du veau

L'expérience avait pour but de déterminer les effets de différents niveaux de protéines provenant du tourteau de soya et différents niveaux de graisses animales dans les moulées destinées à l'engraissement du veau. On a assigné 108 veaux mâles, sevrés à l'âge de 3 jours, de façon factorielle à six traitements, dont trois niveaux de protéines digestibles (9.5%, 11.0% et 12.5%) et deux niveaux de graisses animales (3% et 6%). On a servi du lait entier à raison de 10% du poids vif durant les 2 premières semaines. Pendant la troisième semaine, les veaux ont été transférés graduellement à l'alimentation solide, sauf 12 qui ont continué à recevoir du lait entier jusqu'au poids de 114 kg. La composition des moulées comprenait: 20% de maïs moulu, 45% à 79% de blé moulu, 5% à 15% de tourteau de soya, 0% à 6% de graisses animales, 5% de mélasse, 2% de phosphate dicalcique, 1% de pierre à chaux et 1% de sel iodé.

Le poids initial était d'environ 45 kg. Les veaux à la moulée ont atteint le poids moyen de 114 kg en 124 jours, avec un gain de 0,54 kg par jour. Ceux au lait entier ont atteint le poids de 118 kg en 102 jours, pour un gain quotidien de 0,68 kg. Le rendement des

carcasses était de 51% pour les veaux à la moulée et de 55% pour les veaux au lait entier. Les différents niveaux de protéines et de graisses n'ont pas influencé de façon marquée le rendement de la carcasse, la couleur du muscle et la conversion alimentaire. Les veaux à la moulée ont dû consommer 3,0 kg de matière sèche pour faire 1 kg de gain, alors que ceux au lait entier en consommaient 1,3 kg par kg de gain.

Il en ressort que les veaux à la moulée ont consommé 104 kg de lait entier et 195 kg de moulée pour faire un gain de 69 kg de poids vif en 124 jours, alors que ceux au lait entier ont reçu 945 kg de lait pour réaliser 70 kg de gain en poids vif en 102 jours.

L'influence du taux de croissance sur l'âge à la puberté et l'activité ovarienne de génisses laitières

On a soumis 36 génisses Holstein, pesant chacune 136 kg, à deux régimes alimentaires, l'un à croissance accélérée (FR), l'autre à croissance modérée (MR). Les génisses étaient soumises à l'un ou à l'autre de ces régimes alimentaires soit pendant une phase initiale de 100 jours, soit pendant une phase finale qui se terminait par l'ovariectomie.

Les génisses du traitement FR ont atteint la puberté 16,3 jours plus tôt et pesaient 26,2 kg de plus que les génisses du traitement MR lorsque ces traitements étaient commencés dans la phase initiale de croissance. Lorsque les mêmes traitements étaient commencés au début de la phase finale, l'âge à la première chaleur est apparu 52,0 jours plus tôt chez les génisses soumises au FR alors que leur poids était de 10,0 kg inférieur à celui des génisses MR. Le développement folliculaire était, d'une façon bien marquée, plus accentué sur l'ovaire portant un corps jaune actif. Les génisses soumises au traitement FR durant la période finale de croissance avait développé un deuxième follicule, plus gros que celui des génisses au MR.

Une injection de gonadotropines à la chaleur précédant l'ovariectomie n'a eu pour effet que d'accroître le pourcentage de petits follicules, alors que le taux d'ovulation n'était aucunement changé. Le nombre de *corpora albicantia* observés au moment de l'ovariectomie indiquait que 75% des génisses avaient eu une ovulation avant la puberté, sans toutefois démontrer un oestrus. Des génisses qui démontraient une chaleur à la

première ovulation, 33,3% ont eu un cycle de moins de 10,0 jours.

L'influence du taureau et de l'ouverture pelvienne des génisses sur leurs difficultés de vêlage

On a inséminé 101 génisses croisées de boucherie \times laitière à la première chaleur suivant l'âge de 365 jours, avec de la semence d'un taureau Angus ou d'un Limousin, dans le but d'étudier l'influence de la race du père, du poids du veau et de l'ouverture pelvienne de la mère, sur l'assistance au vêlage (AV). On a mesuré la hauteur et la largeur de l'ouverture pelvienne au vêlage et coté le degré d'AV de 1 (nul) à 5 (maximum).

Le pourcentage et la cote moyenne d'AV pour les génisses ayant une ouverture pelvienne plus petite que la moyenne ont été de 25,0% et 2,1 lorsqu'elles étaient saillies par un taureau Angus et de 37,5% et 2,5 lorsque saillies par un taureau Limousin. Dans le cas de génisses avec une ouverture pelvienne plus grande que la moyenne, le pourcentage et la cote moyenne d'AV ont été de 12,5% et 2,0 lorsque saillies par un taureau Angus et de 18,8% et 2,1 lorsque saillies par un taureau Limousin.

L'expérience était en même temps poursuivie à l'Université Laval où 77 génisses croisées étaient saillies, d'après leurs poids, avec de la semence d'un Angus ou d'un Shorthorn. Le pourcentage et la cote moyenne d'AV pour les génisses ayant une ouverture pelvienne plus petite que la moyenne ont été de 29,4% et 2,6 lorsque saillies par un taureau Angus et de 41,7% et de 2,2 lorsque saillies par un taureau Shorthorn. Dans le cas de génisses avec une ouverture pelvienne plus grande que la moyenne, le pourcentage et la cote moyenne d'AV ont été de 25,0% et 2,3 lorsque saillies par un taureau Angus et de 20,8% et 2,2 lorsque saillies par un taureau Shorthorn.

Chez les veaux, les structures anatomiques les plus importantes par rapport au AV étaient la circonférence du nez et de la tête, la ceinture du coeur et la largeur de l'épaule. Le sexe du veau n'a eu aucune influence sur le degré d'AV.

Croissance rapide et croissance lente des bouvillons croisés

On a élevé 178 bouvillons sur deux régimes alimentaires, l'un à croissance rapide (CR) et l'autre à croissance lente (CL). Ils

étaient issus de taureaux Charolais, Hereford et Limousin et de vaches Holstein-Frison et Ayrshire. Leur poids initial moyen était de 185 kg et leur poids à l'abattage de 545 kg. Les bouvillons du régime CR sont toujours restés en stabulation libre et ouverte et ont reçu jusqu'à 8,2 kg de moulée avec un peu de foin. Ceux du CL se sont alimentés uniquement de pâturage en été, tandis qu'en hiver, ils ont consommé 7,3 kg de foin par jour et un peu de moulée.

Les bouvillons du régime CR ont converti leurs aliments en viande de façon plus efficace que ceux du CL (5,8 par rapport à 11,1). Ils ont fait 0,42 kg de gain de plus par jour que les autres et ont atteint le poids d'abattage 306 jours plus tôt. Les bouvillons à croissance rapide ont aussi eu un rendement à l'abattage de 2% supérieur, une couche de gras 5,7 mm plus épaisse et une surface de muscle dorsal (noix de côte) de 5 cm² plus étendue que ceux à croissance lente. Toutes ces différences furent significatives ($P < 0.01$). Les bouvillons du régime CL ont fait perdre, en moyenne, par année, \$27.50 alors que les autres ont fait réaliser un profit moyen de \$14.

Les bouvillons de descendance charolaise ont eu le gain quotidien le plus rapide et ont atteint le poids du marché les premiers. Ceux de descendance limousine, élevés au régime CR, ont eu le plus haut pourcentage de rendement à l'abattage (58%). Ils ont aussi obtenu la surface du muscle dorsal la plus étendue, quel que soit le régime. Quant aux bouvillons issus de père Hereford, ils ont obtenus les couches de gras les plus épaisses et les surfaces du muscle dorsal les plus petites. Ceux du régime CR furent les plus rentables, tandis que ceux du CL ont fait la plus grande perte.

Il n'y a pas eu de différence significative entre les bouvillons de descendance Holstein et ceux issus d'Ayrshire.

L'apparition de l'anémie du chou fourrager chez les ruminants

Dans une première expérience, du chou fourrager fertilisé à 0, 150 et 300 kg/ha de N a été donné à des groupes de 4 vaches en gestation. Un groupe supplémentaire de 4 vaches alimentées à l'ensilage d'herbe a servi de traitement témoin. Les teneurs en protéines brutes ont été de 9.6%, 9.0%, 15.4% et 11.4% et en N-NO₃ de 0.028, 0.030, 0.185 et 0.015 pour le chou fourrager fertilisé à 0, 150

et 300 kg/ha de N et l'ensilage d'herbe respectivement. A la fin de la cinquième semaine d'alimentation on a observé des teneurs en hémoglobine du sang de 12,3 g/100 ml et en hématocrite de 35.4% chez les vaches alimentées à l'ensilage d'herbe, soit des valeurs aussi élevées qu'au début de l'essai. Par ailleurs, les teneurs en hémoglobine et en hématocrite du sang des vaches alimentées au chou fourrager avaient diminué étant de 9,56, 9,29 et 9,86 g/100 ml pour l'hémoglobine et de 28.4%, 28.8% et 28.8% pour l'hématocrite avec le chou fourrager à 0, 150 et 300 kg de N/ha respectivement. On a conclu que le niveau de fertilisation azotée du chou fourrager n'a pas d'influence sur l'apparition de l'anémie.

Dans une deuxième expérience, du chou fourrager déshydraté à haute température (95°C) et de l'ensilage de chou fourrager ont été servis à des groupes de 4 moutons pendant 3 mois. Un groupe supplémentaire de 4 moutons alimentés au foin et au concentré a servi de traitement témoin. Les teneurs en protéines brutes ont été de 12.29% et 14.96% et en N-NO₃ de 0.124% et 0.272% pour l'ensilage et le chou fourrager déshydraté respectivement. Les teneurs en hémoglobine et en hématocrite ont été aussi élevés pour les moutons alimentés au chou fourrager que pour ceux alimentés au foin et aux concentrés indiquant ainsi que la chaleur et le processus d'ensilage détruisent l'agent toxique qui cause l'anémie du chou fourrager.

Mortalité embryonnaire et développement des foetus chez trois races de truie

Nous avons mesuré le taux d'ovulation, la grosseur des portées et le poids des placentas, des foetus et des cornes utérines aux 23, 42 et 63 jours de gestation, de 138 truies multipares de races Yorkshire, Landrace et Lacombe. Les truies étaient saillies par des verrats Yorkshire, Landrace ou Hampshire de façon à engendrer des portées de race et des portées croisées.

Des 53 truies Yorkshire abattues, 13.2% étaient non gestantes par rapport à 7.5% et 8.5% pour les Landrace et les Lacombe respectivement. Le nombre moyen de corps jaunes rencontrés chez les Landrace était de 15.1 par rapport à 14.1 pour les Yorkshire et Lacombe. Le taux de mortalité des embryons croisés était de 7.5% et 6.0% plus élevé chez les Landrace que chez les Yorkshire et les Lacombe respectivement. La mortalité des

embryons de race était de 8.4% plus élevé chez les Landrace que chez les Yorkshire. Les portées issues de verrats Yorkshire étaient en moyenne 7.8% plus nombreuses que celles issues de verrats Landrace ou Hampshire.

Le 23^e jour de gestation, 19% des oeufs relâchés étaient perdus; on a enregistré une perte additionnelle de 4% aux autres jours étudiés. Le poids des embryons Landrace et Lacombe était plus élevé que celui des Yorkshire. Les embryons croisés de truies Yorkshire et Landrace étaient plus lourds que les embryons de race et ce, de 27%, 8% et 6% aux 23^e, 42^e et 63^e jours de gestation, respectivement.

Les cornes utérines et les membranes placentaires étaient plus lourdes chez les Landrace et les Lacombe que chez les Yorkshire. On a noté très peu de différence entre les races Landrace et Lacombe pour le poids des foetus, des membranes placentaires et des cornes utérines. Les corrélations entre le poids des membranes placentaires et celui des foetus, pour les trois stades étudiés, étaient de 0.65, 0.57, 0.76 respectivement et très significatives. La corrélation entre le nombre d'embryons viables et la longueur des cornes utérines était de 0.30 alors que celle entre le nombre d'embryons viables et le poids des cornes était de 0.10.

PRODUCTIONS VÉGÉTALES

Facteurs limitant la survie à l'hiver des luzernières du sud-ouest du Québec

Durant l'hiver 1973-1974, on a relevé les facteurs impliqués dans l'adaptation et la survie de la luzerne à l'hiver. On a prélevé périodiquement des échantillons de luzernières en semis pur sur des types de sol représentatifs de la région.

De chaque échantillon, quelques plants étaient soumis à un test de congélation, afin de mesurer leur degré d'adaptation au froid, tandis que les autres étaient transférés en serre pour connaître leur taux de survie à l'hiver. Cette technique nous permettait donc de connaître l'état des luzernières à n'importe quelle période de la saison froide. De plus, on a déterminé l'humidité des sols à 10 cm de profondeur lors de l'échantillonnage.

A la mi-décembre, la survivance de la luzerne était dans un état satisfaisant. Au début du mois de janvier, les champs ont été complètement recouverts de glace à la suite

de fortes précipitations de pluie. Puis, une vague de froid intense s'est abattue sur les couronnes de luzerne sans protection. Ces conditions climatiques défavorables ont fait que les degrés d'adaptation et les taux de survie ont diminué radicalement pour atteindre un niveau inférieur à 20% dès la fin de janvier. Les luzernières étaient déjà loin en dessous d'un niveau acceptable de survie.

On a constaté aussi que le taux de survie diminue très rapidement dans la mesure où le pourcentage d'humidité du sol augmente au cours de l'hiver. Il appert qu'une augmentation de 10% ou plus de la teneur en eau du sol gelé, entre décembre et février, soit fatale pour la survie de la luzerne.

Dans l'ensemble, nos résultats nous ont permis d'établir que le seuil critique était déjà dépassé au mois de février. Notre technique nous fait donc connaître l'instant même où les dommages se produisent et nous permet aussi la recommandation d'une régie appropriée avant le début de la saison de végétation.

Effet du régime hydrique et du pH des sols sur la teneur en manganèse de la luzerne et du lotier

Le manganèse est un des éléments responsables du pauvre comportement des légumineuses en sols acides. Nous nous sommes donc servis de la teneur en Mn du sol et des plantes comme moyen d'évaluer l'interaction existant entre le pH du sol et son régime hydrique. On a cultivé, en serre, de la luzerne et du lotier sur l'argile Ste-Rosalie et le sable St-Jude ajustés aux pH 4.8, 6.6 et 7.5. Les régimes hydriques comparés étaient très humide, optimum et très sec.

En régime hydrique très humide, la teneur en manganèse échangeable a augmenté de 18% par rapport à celle du sol d'humidité optimale. L'effet de l'humidité s'est manifesté surtout en argile Ste-Rosalie de pH 5.1 où le manganèse échangeable du sol s'est accru de 3.51 ppm à 6.15 ppm quand le sol a été soumis à un régime hydrique très humide (entre point de saturation et capacité aux champs). En régime très sec (entre 40% de capacité aux champs et point de flétrissement) la teneur en Mn échangeable a été légèrement réduite.

L'augmentation du pH des sols à la suite du chaulage a extrêmement diminué les teneurs en Mn échangeable. Elles se sont chiffrées en moyenne à 3.59 ppm, 1.36 ppm

et 1.06 ppm de Mn pour les sols dont les pH avaient été fixés à 4.8, 6.6 et 7.5 respectivement.

La diminution de la teneur en Mn échangeable à la suite du chaulage a été beaucoup moins marquée en sol humide qu'en sol sec et également beaucoup moins prononcée en sable St-Jude qu'en argile Ste-Rosalie.

Dans la plante, la teneur en Mn a été nettement fonction du pH du sol. On y a dosé 252 ppm, 99 ppm et 79 ppm de Mn en moyenne pour la luzerne et le lotier cultivés sur des sols de pH 4.8, 6.6 et 7.5 respectivement.

Les régimes hydriques du sol n'ont pas tellement influencé la teneur en Mn des

plantes si ce n'est dans le cas où elles croissaient sur sol chaulé au pH 7.5. On a alors trouvé un peu plus de Mn dans la luzerne et le lotier soumis à des régimes hydriques très humides.

Les deux sols non chaulés contenaient à peu près la même quantité de Mn échangeable soit 3.5 ppm. Cependant, les plantes provenant du sable St-Jude de pH 5.0 dosaient 361 ppm de Mn comparé à 142 ppm pour l'argile Ste-Rosalie. On sait que ce dernier sol contient 17 fois plus de magnésium que le sable St-Jude. Cette haute teneur en magnésium a vraisemblablement freiné l'absorption du manganèse par la luzerne croissant sur l'argile Ste-Rosalie.

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¹Détaché de la Direction de l'économie du ministère de l'Agriculture du Canada.

INTRODUCTION

La Station de Recherches de Sainte-Foy s'identifie de plus en plus aux problèmes agricoles du centre de la province de Québec et des régions du Bas St-Laurent et du Lac Saint-Jean.

En 1974 nous avons fait homologuer la nouvelle variété d'avoine «Alma» dont la semence sera bientôt disponible à tous les cultivateurs.

Ce rapport présente certains des résultats obtenus en 1974. Il faut adresser toute demande de renseignements à: Station de recherches, Agriculture Canada, 2560 Chemin Gomin, Sainte-Foy, Québec G1V 2J3.

Le Directeur
S. J. Bourget

LES PLANTES

L'endurcissement au froid

Depuis un peu plus d'un an on a poursuivi une étude sur la méthodologie d'un test de tamisage pour la résistance au froid et la génétique de celle-ci. Le test de tamisage en est présentement à sa deuxième phase. A la première phase nous avons démontré qu'il est possible d'obtenir des F_1 qui sont significativement plus résistantes au gel que leur parent. Les F_1 ont mieux survécu et produit plus de repousses que le parent Angus. Elles tolèrent $1,4^{\circ}\text{C}$ plus de froid que le parent Angus. Après la première récolte de la deuxième phase il appert que les F_2 ont déjà moins de tolérance au froid que les F_1 et guère plus que le parent Angus. Il faudra attendre une deuxième, voire même une troisième coupe pour tirer les conclusions. En génétique, un croisement diallèle à partir de cinq plantes du cultivar Angus, ayant survécu à un gel de -14°C et -16°C , a été évalué. Ces cinq plantes ont démontré des aptitudes générales et spécifiques à la combinaison pour certains caractères morphologiques responsables du rendement. Un autre essai a démontré que même à la F_1 il est possible d'obtenir une aptitude générale à la combinaison pour ce que nous appelons l'index de survie (survie \times rendement en matière sèche). Là encore une deuxième et une troisième coupe seront nécessaires pour confirmer ou infirmer ces résultats préliminaires.

Les lipides. Le marquage des lipides des racines a montré que la stimulation de l'élongation et de la désaturation des acides gras à basse température, stimulation plus prononcée chez Rambler que chez Caliverde,

se maintient au cours de l'endurcissement, à l'exception d'une répression spécifique de la désaturation de l'acide oléique en acide linoléique. La stimulation à basse température de la synthèse de l'acide linoléique de la phosphatidyl choline, surtout chez la variété Rambler, suggère que la phosphatidyl choline est étroitement liée à la désaturation de l'acide oléique et de son contrôle au cours de l'endurcissement. Les changements observés se produisent avant l'augmentation de la résistance à la gelée. Ils semblent donc un prérequis à l'endurcissement chez la luzerne. Quoique la synthèse des stérols libres soit très active dans les racines de la luzerne, la radioactivité incorporée dans les esters de stérols, faible au début de l'endurcissement mais très importante à la fin de celui-ci, surtout chez la variété tendre Caliverde, ne se retrouve que dans la partie acide gras de ces composés. Le dosage du phosphore lipidique des racines indique une augmentation des phospholipides chez la variété rustique Rambler et une diminution de ceux-ci chez la variété tendre Caliverde au cours de l'endurcissement.

Au cours de l'endurcissement du blé d'hiver en conditions contrôlées, l'incorporation du ^{33}P dans les lipides est stimulée fortement chez la variété rustique Kharkov mais peu chez la variété tendre Champlain. Il n'y a cependant que peu de changements qualitatifs des phospholipides au cours de l'endurcissement. Il y a peu de corrélation entre l'augmentation de la synthèse des phospholipides et l'endurcissement. Cette augmentation ne semble donc pas être un prérequis à l'endurcissement, quoique un taux élevé de synthèse des phospholipides peut être nécessaire au maintien de la résistance à la gelée. Le dosage du phosphore lipidique des racines

de blé indique peu d'augmentation de celui-ci au cours des deux premières semaines d'endurcissement.

La proline. Il existe une corrélation entre la synthèse de la proline dans les feuilles de luzerne et le degré d'endurcissement atteint par la plante endurcie à 1,5, 5,0 et 10°C. A 5° et 10°C, après avoir atteint un maximum, l'endurcissement et la synthèse de la proline diminuent comme si la plante s'adaptait à ces températures et pouvait croître à nouveau.

La proline s'accumule plus rapidement dans les couronnes et les racines soumises à des températures d'endurcissement de 5° et 10°C qu'à celle de 1,5°C. Après 3 semaines elle diminue aussi plus rapidement à 5° et 10°C qu'à 1,5°C. Ces résultats semblent démontrer que la proline synthétisée dans les feuilles serait transportée dans les couronnes et les racines moins rapidement à 1,5°C qu'à 5° et 10°C et qu'à ces températures, après une période d'adaptation, la plante utiliserait à nouveau ses réserves de proline.

Les protéines. On a étudié le point de congélation (Π) du suc cellulaire exprimé chez quatre variétés de plantules de blé d'hiver endurcies pendant 0, 10 et 20 jours. La température léthale (LT_{50}) était en corrélation significative avec Π aux jours 0 et 20 de l'endurcissement. Au jour 10 la LT_{50} observée était plus basse que prévue. La différence entre les valeurs observées et prévues pour la LT_{50} indique la possibilité d'un second mécanisme d'endurcissement, autre que l'augmentation en concentration des solutés dans les tissus.

On a étudié le taux d'incorporation des protéines nouvellement synthétisées dans les fractions subcellulaires des tissus de la racine et du collet chez le blé d'hiver au cours des 15 premiers jours de l'endurcissement. Une incorporation significative a été observée dans les protéines du surnageant après centrifugation des mitochondries et microsomes. Cette incorporation a atteint un maximum après 11 jours d'endurcissement et était plus grande chez la variété rustique Kharkov que chez la variété tendre Champlain. L'analyse des acides aminés des protéines non purifiées de cette fraction indique des changements dans les teneurs en méthionine et en acide stéarique.

L'humidité du sol. Afin de déterminer l'influence de l'humidité du sol sur l'endurcissement au gel de la luzerne, on a placé des

plants endurcis durant 2 à 4 semaines dans des boîtes isolées de façon à ne laisser pénétrer le froid qu'à la surface des pots. Les résultats ont montré qu'effectivement la résistance au gel des plantes est inversement proportionnelle au degré d'humidité du sol. Dans un sol relativement sec (10% d'humidité) les plants non endurcis ont un seuil de résistance (DL_{50} = température où le taux de mortalité atteint 50%) inférieur de 2°C comparativement à un sol demi-saturé ou saturé. Après 2 et 4 semaines d'endurcissement, la différence du seuil de résistance entre le sol sec et le sol saturé atteint 4° à 6°C ce qui peut signifier sous certaines conditions climatiques la vie ou la mort de la luzerne.

Le trèfle rouge

Dans une expérience sur la longévité, des cultivars de trèfle rouge ont maintenu leur production et leur vigueur même après une période continue de plus de 10 mois. Ceci impliqua 10 récoltes pour un cultivar tardif dit d'une coupe et jusqu'à 14 pour les cultivars hâtifs. Une variété tardive diploïde a donné le meilleur rendement total. Les variétés tardives tétraploïdes ont donné en moyenne une meilleure récolte que les hâtives diploïdes. A la fin de l'essai nous n'avions perdu que deux plantes sur 324 et aucune maladie interne n'a été décelée. Seul le mildiou poudreux a été observé sur les feuilles.

La luzerne

Taches foliaires. Des nombreuses observations faites au cours de quelques années, il ressort qu'on ne peut considérer uniquement la tache commune, mais plutôt le complexe de taches foliaires causées par les organismes pathogènes suivants: *Phoma medicaginis* Malbr. & Roum., *Cercospora zebrina* Pass., *Leptosphaerulina briosiana* (Poll.) Graham & Luttrell, *Peronospora trifoliorum* de Bary, *Pseudopeziza trifolii* & sp. *medicaginis-sativae* Schmied., *Leptotrichila medicaginis* (Fckl.) Schüepp, *Stemphylium botryosum* Walbr. Plusieurs de ces organismes pathogènes peuvent se manifester ensemble ou à tour de rôle, par groupe de deux, trois ou plus, à différents moments de la saison de végétation.

Pourriture. Un inventaire effectué à travers la province dans plusieurs luzernières d'âges différents nous révèle que partout la luzerne est affectée par la nourriture de la couronne à

divers degrés selon l'âge et la localité. Des essais d'isolation des micro-organismes associés à la pourriture, essais effectués pour déterminer la séquence d'infection, ont révélé, par ordre de fréquence, la présence du *Fusarium solani* (Mart.) (Appel et Wr.) Sn. et H., *F. oxysporum* (Schlecht.) Sn. et H., *F. roseum* (Link) Sn. et H. et *F. tricinctum* (Cda.) Sn. et H.

Les Rhizobium

Une étude entre le métabolisme oxydant du *Rhizobium* en culture in vitro et sa capacité à fixer symbiotiquement l'azote atmosphérique sur la luzerne nous indique qu'il y a une corrélation intéressante. Les mesures de la consommation d'oxygène et de mannitol au cours de la croissance exponentielle du *Rhizobium*, en regard du taux de synthèse des protéines cellulaires, nous ont permis d'établir des corrélations avec l'efficacité symbiotique des souches. Nous sommes à essayer plusieurs courbes de régression en vue d'obtenir les paramètres physiologiques que nous utiliserons pour évaluer les souches.

Nous avons continué en 1974 l'enquête entreprise au Québec afin d'acquérir plus de renseignements sur la qualité des inoculants commerciaux des légumineuses tels qu'ils sont distribués aux cultivateurs. Ce projet se réalise en collaboration avec le Département d'Agrobiologie de l'Université Laval et le Ministère de l'Agriculture du Gouvernement du Québec. Nos résultats indiquent que de sérieux problèmes existent au niveau de la commercialisation des inoculants et c'est ce qui affecte grandement la qualité des produits offerts aux cultivateurs. Ainsi, pour les inoculants mixtes trèfle-luzerne, sur un total de 75 échantillons achetés en mai 1974 chez des distributeurs de la province, 8 étaient passés date; seulement 10 des 57 échantillons testés étaient satisfaisants pour le trèfle et 28 pour la luzerne. Un problème semblable existe aussi pour les autres inoculants des légumineuses, telles la fève soja et la féverole. En plus du mauvais entreposage des inoculants et des produits passés date, nous avons constaté que le nombre de cellules viables par gramme d'inoculant est trop faible pour assurer une bonne nodulation.

Le mil

Hespérie européenne. Un inventaire effectué dans toute la province en collaboration avec l'Université Laval démontre une importante augmentation de l'aire de distribution de l'insecte et une intensification de l'épidémie dans trois régions différentes: Ville-Marie, Joliette et St-Félicien. Dans cette dernière région nous avons fait des tests pour mesurer l'effet de l'hespérie sur le rendement en matière sèche et le rendement en protéines à l'acre. On étudie également le rendement en graine de mil. L'analyse des données n'est pas complétée mais les fermiers insistent sur la gravité de la situation et déclarent des pertes de 30% à 50%.

On peut déjà conclure à l'urgence de fournir des mesures de répression immédiate aux régions où l'hespérie est épidémique. On recommande l'insecticide microbien *Bacillus thuringiensis* pour 1975. Il faudra cependant accorder une plus grande attention aux agents biologiques qui ont le potentiel de donner un contrôle plus efficace, plus durable et moins coûteux. Mentionnons le virus (type polyhédrose nucléaire) découvert à Normandin par le Dr Vladimir Smirnoff (Environnement Canada), lors d'une épizootie naturelle, et aussi le parasite *Stenichneumon scutellator* que le Dr K.P. Carl (*Commonwealth Institute of Biological Control*) recherche pour nous en Europe. Le travail de ces deux collaborateurs mérite une haute priorité. Le Dr Smirnoff a préparé 320 gallons de virus concentré à partir de larves malades récoltées dans le secteur de Normandin avec notre collaboration.

Les céréales

Enquêtes pathologiques. Les données recueillies au cours d'une enquête de 3 ans dans les parcelles d'essais de céréales du C.P.V.Q. (Conseil des productions végétales du Québec) indiquent une diminution de l'incidence et de la sévérité des rayures et des taches des feuilles de céréales. Ainsi, la septoriose de l'avoine qui au cours de la dernière décennie avait connu un sommet entre 1966-1968 est maintenant à son plus bas niveau. Il en est de même pour l'helminthosporiose de l'orge. Dans la région de St-Hyacinthe cependant, la septoriose du blé se maintient. Les rouilles des feuilles du blé, de l'orge et de l'avoine sont plus abondantes dans l'ouest de la province et semblent causer plus de dommages. La rouille de l'avoine a

été particulièrement sévère à Ste-Anne-de-Bellevue, au cours des deux dernières années. Ailleurs en province, l'arrivée des rouilles est tardive et n'a généralement pas d'effet sur le rendement. Parmi les cultivars à l'essai, l'avoine Alma, le blé Maderes et l'orge Loyola sont particulièrement résistants aux rouilles des feuilles.

L'avoine

Évaluation. Les essais coopératifs de l'est du Canada ont permis d'évaluer deux lignées pour leur adaptabilité et leur rendement. La lignée Q.O. 130.4 semble prometteuse et a été retenue pour une autre année d'évaluation. Suite à la preuve de la tolérance à *Septoria* de la lignée Q.O. 115.1.2, on a homologué cette dernière sous le nom de «Alma» en 1974.

Amélioration. Quelque 180 croisements ont été réalisés en 1974 pour répondre aux objectifs du Québec et des Maritimes en plus de plusieurs objectifs spéciaux tels que grain nu, paille naine, efficacité physiologique, combinaison gros grain et bas pourcentage d'écale et résistance au *Septoria*. La modification du schéma de sélection a permis de sélectionner pour le rendement, la maturité et la longueur de la paille, plus de 900 lignées F_6 et F_7 dont la moitié était des sélections pour la résistance contre le virus du jaunissement des feuilles. Quelque 2000 lignées F_4 ont été sélectionnées de la même façon pour une deuxième année consécutive. Dans le cadre du Groupe du Québec, quelque 250 lignées étaient évaluées en F_7 . Ce matériel représente plusieurs croisements dont un avait 137 lignées qui ont toutes battu le témoin à haut rendement l'an dernier; il y a donc du matériel d'une grande valeur dans ces essais. Quelques lignées étaient évaluées en F_8 et F_9 .

Pour satisfaire aux exigences en amélioration des Maritimes, en plus de la réalisation de plusieurs croisements, quelque 250 lignées ont été évaluées à Charlottetown pour trouver les mieux adaptées avec un rendement supérieur et une bonne paille. Les quelque 50 lignées évaluées l'an dernier se sont très bien comportées pour le rendement et la force de la paille et ont fait l'objet d'un nouveau test. Les lignées les plus prometteuses l'an dernier ont été évaluées cette année dans les tests régionaux à six stations dans les Maritimes.

Influence de la tige principale. Suite à des observations préliminaires qui semblaient

indiquer que la tige principale avait un apport déterminant sur le rendement, une étude a été faite en impliquant le type de sol, le taux et la date de semis pour des variétés pures et des mélanges. L'analyse des résultats de la première année démontre qu'il n'y a aucune corrélation entre le poids de la tige principale à maturité et le rendement.

Septoriose. On a effectué pour la deuxième année consécutive une étude comparative sur la tolérance et la résistance de cultivars d'avoine à la septoriose de l'avoine. Trois traitements: (a) une inoculation naturelle (b) une application continue de fongicide à tous les 10 jours et (c) une inoculation artificielle furent effectuées sur quatre replicata de six cultivars à trois endroits dans l'est du Canada. Cette étude démontre que l'application du fongicide manèbe a augmenté le rendement moyen de l'avoine à chaque site. L'inoculation artificielle a réduit le rendement de cultivars moins tolérants. Généralement, l'inoculation artificielle en comparaison avec le témoin n'affectait pas de façon significative le poids de 1000 grains et le pourcentage d'écale. Les symptômes étaient généralement plus abondants dans les parcelles inoculées artificiellement surtout en 1974 où l'inoculum naturel était peu abondant. Parmi les cultivars, CI 8175 était le moins sensible et Cabot le plus sensible aux trois endroits. Alma était aussi tolérante que Dorval et Scott et son rendement était comparable en ayant toutefois un poids de 1000 grains légèrement inférieur et un pourcentage d'écale supérieur aux deux autres cultivars.

La méthode des essais sur explantats de feuilles d'avoine a été supérieure à celle des essais sur gélase dans notre étude sur l'efficacité de divers fongicides contre la septoriose de l'avoine.

Lors d'une étude en parcelles avec trois cultivars, on a trouvé qu'il existe une interaction positive et même synergique entre le virus de la feuille rouge et la septoriose de l'avoine. Les critères utilisés ont été la quantité de symptômes développés, le rendement, le poids de 1000 grains et le pourcentage d'écale.

L'orge

Sur les 30 lignées au croisement Q.B. 136 évaluées en 1973, nous en avons retenu 10 que nous avons incluses dans l'essai de tamisage à six stations. Soixante-et-trois

nouvelles ont été en essai d'observation à trois stations. Nous avons continué d'étudier l'effet des stations sur la sélection naturelle de populations massales d'orge. Une étude en serre nous a permis de montrer que nous pouvons contrôler le tallage de l'orge, de l'avoine et du blé en changeant la configuration spatiale du semis. Un semis de quatre grains à chaque demi-pouce a presque complètement contrôlé le tallage. L'apport de nouveau matériel génétique au programme d'amélioration a été assuré par l'introduction de 13 lignées importées de Chine. Une sélection intensive des populations en disjonction s'est poursuivie.

LES SOLS

Fertilité

Matière organique. Une étude sur les propriétés de l'humus, dans 19 des principales séries de sols utilisées pour la grande culture au Québec, a démontré que le carbone sous forme d'humus augmentait de 2% à 5% de l'ouest vers l'est du Québec. La moitié de cet humus est sous forme d'humine et sous forme non hydrolysable avec de l'acide. Les résultats ont aussi permis de conclure que les types pédologiques (Gleysols ou Brunisols et Podzols) et le pH n'affectent pas les propriétés de l'humus dans les horizons Ap, mais que l'accumulation des degrés-jours et le contenu en argile y jouent un rôle significatif. Le pH a été le seul facteur qui affectait de façon significative les propriétés de l'humus dans les horizons B. Dans tous les sols, l'augmentation du carbone était reliée avec l'augmentation des acides fulviques au détriment des acides humiques.

On a utilisé la datation au radiocarbone pour mesurer l'âge moyen de l'humus des sols. Il appert que l'humus de l'horizon Ap de la série Kamouraska, échantillonnée à La Pocatière, est moderne. Toutefois, 17% du carbone qui se trouvait sous forme d'acides humiques montra 1220 ans et 55% du carbone non hydrolysable à l'acide 1530 ans. Ces premiers résultats indiquent qu'une bonne proportion de l'humus est très résistant même à la surface des sols cultivés au Québec. Une dizaine d'autres échantillons de sol seront étudiés en 1975.

Nutrition minérale. De l'avoine à cinq sites, de l'orge à trois sites et du blé à deux sites ont été semés dans le cadre d'une étude sur le

calibrage des sols. Seize traitements de fertilisants ont été utilisés. Ces expériences ont eu lieu dans la région du Lac St-Jean. Les rendements en grain ne sont pas encore connus sauf pour le blé à un endroit. Dans ce cas les rendements moyens du grain ont varié de 2543 à 3273 kg/ha selon les traitements.

En serre, une expérience sur l'effet d'une fertilisation en N, P, K et S sur la luzerne pour deux sols a été complétée. Contrairement à ce qui était attendu, le sol St-André a donné des rendements beaucoup plus élevés que le sol Kamouraska, ce qui pourrait s'expliquer par la compacité de ce dernier sol, suite aux fréquents arrosages. Les rendements moyens pour les cinq coupes ont varié de 62,6 à 78,7 g de matière sèche par pot sur le sol St-André et de 37,2 à 51,8 g de matière sèche par pot sur le sol Kamouraska.

Critères de classification

Horizons indurés. Dans les Appalaches, on a établi des profils de densité partant de la surface et descendant, au moins dans un cas, jusqu'en dessous de l'horizon induré, à 2,40 m de profondeur. En général, la densité dans la partie supérieure des profils est inférieure à 1. Dans l'horizon de transition, à environ 50 cm de profondeur et d'épaisseur variable (10 à 20 cm), on a mesuré des valeurs de densité de 1,5 à 1,65. Ensuite, les valeurs passaient rapidement à plus de 1,9 et pouvaient même atteindre 2,05. Cependant, l'examen morphologique du profil montre, en plus des fentes de retrait typiques (*gray streaks*) des faces de clivage et une structure lamellaire qui suggèrent qu'en dessous de l'horizon très compact qui forme le dessous du fragipan, les fluides sont susceptibles de circuler plus ou moins facilement. Il est impossible de faire des mesures de conductivité en place dans ces sols très pierreux et on a donc prélevé une trentaine d'échantillons pour travailler en laboratoire.

Dans les basses Laurentides, l'analyse de quelques profils des séries Ste-Agathe et Gatineau a permis de faire des comparaisons avec les horizons indurés des Appalaches. Ce sont des sols à texture plus sableuse mais on retrouve cependant plusieurs horizons avec des densités de l'ordre de 2. A première vue les profils sont plus perméables, mais il y a quand même une limitation pour la pénétration des racines et un début d'induration. Celui-ci présente plusieurs différences avec le fragipan: absence des fentes de retrait, due à

la texture, et différences dans les phénomènes de dispersion dans l'eau. Par contre, on retrouve les phénomènes de fragilité et de dureté quand le profil sèche.

FERME EXPÉRIMENTALE LA POCATIÈRE

Plantes fourragères

Fertilisation. L'azote a augmenté le rendement du trèfle rouge dans cinq cas sur six tandis que celui de la luzerne n'a à peu près pas été influencé. Le rendement n'a pas toujours répondu positivement aux apports de phosphore. Le potassium avait tendance à accroître les rendements de la première coupe plus que ceux de la deuxième. Le placement du phosphore en bandes à côté de ou avec la semence a augmenté les rendements; par contre, le placement en dessous de la semence a été moins efficace que les autres placements.

Régie de coupe. Le trèfle rouge a réagi à la coupe. Coupé en une seule fois, la meilleure production est obtenue avec la coupe la plus tardive; coupé plus d'une fois, c'est avec la combinaison première coupe et la date la plus éloignée de cette première coupe que le rendement est le plus élevé. La combinaison d'une première coupe avec différents intervalles pour les autres coupes donne toujours un rendement supérieur à une seule coupe peu importe la date de ces coupes.

La luzerne coupée après le gel a donné un rendement plus faible que celle qui n'a pas été coupée. Le nombre de degrés-jours écoulés entre la première et la seconde coupe influence aussi le rendement de l'année suivante.

Régie du semis. La luzerne semée en août 1971 a donné un rendement supérieur au semis du printemps 1971. Le taux de semis a influencé positivement le rendement du semis du printemps. Semée en août 1972, la variété Alfa a rendu plus que si elle avait été semée au printemps 1972, tandis que l'inverse s'est produit pour Vernal et Narragansett. On note peu de différence dans le rendement des différentes dates de semis du printemps 1973, mais en août il diminue avec le retard de la date de semis et le meilleur rendement du printemps l'emporte légèrement sur le meilleur d'août. Il y a peu d'influence de la date

sur le rendement d'un semis du printemps 1974.

L'association en rangs alternés de la luzerne et du mil a donné des rendements supérieurs aux semis en mélanges et purs. Le semis en rangs a été supérieur au semis à la volée pour le mil et la luzerne en culture pure.

Les céréales

Fertilisation. Plus les semences étaient tardives, plus bas étaient les taux d'azote et de phosphore donnant le maximum de rendement de l'orge. Pour le blé de printemps, l'azote était légèrement le plus important sur deux types de sol. Le phosphore était important sur le trèfle de l'Anse. En général, le rendement des céréales a augmenté quand le pourcentage d'azote avec la semence augmentait.

Des expériences sur deux types de sol ont démontré que le cultivar Dorval (sensible au BYDV) était supérieur à Pendek (relativement résistant au BYDV) en rendement en grain. Avec de l'azote, les pucerons (BYDV) ont diminué le rendement plus chez Pendek que chez Dorval mais cette diminution était moindre avec une augmentation de la dose. Avec le phosphore, les rendements ont plus diminué chez Dorval que chez Pendek. La diminution était beaucoup moins forte pour les deux variétés quand le phosphore était plus élevé. Avec le potassium, les rendements ont diminué autant ou plus chez Dorval que chez Pendek.

Régie. Sur un retour d'orge, un hersage à l'automne constitue une bonne préparation du sol pour l'orge là où il n'y a pas de chiendent; lorsque le chiendent ou le mil présente des problèmes, il est nécessaire de herser au printemps surtout si le semis est retardé. Le chiendent (entre 1 et 25 plants par m²) peut causer une réduction de 25% à 70% de la matière sèche de l'orge. On a obtenu une répression de 90% du chiendent avec du glyphosate (1,12 à 2,24 kg/ha) appliqué à l'automne.

Les pommes de terre

Régie. L'EPTC employé à 8.96 kg/ha n'a enrayé le chiendent qu'à 50% cependant que l'addition de métribuzine (0,64 kg/ha) à 3,36 kg/ha d'EPTC a réduit de 88% cette adventice. Les mélanges paraquat-alachlor (0,64 et 2,24 kg/ha) et paraquat-linuron (0,64 et 1,12 kg/ha) ont réduit le chiendent de 91% et 97%

respectivement lorsqu'employés à la sortie des pommes de terre.

Flétrissure bactérienne. Le climat a été moins favorable à l'expression des symptômes. Conséquemment, les désinfectants ont été plus efficaces pour désinfecter les contenants. Les nouveaux cultivars H1-Plains, Nook-Sack, Noordeling, Pentland Ace, Wash 284-RV et Voran sont apparus sensibles à la maladie. Un seul cultivar de Fredericton n'a pas montré de symptômes après inoculation des racines. Les cultivars tolérants à l'organisme pathogène et inoculés en 1973 n'ont pas tous véhiculé la maladie au cultivar sensible G.M.D. d'où l'importance de rechercher des cultivars vraiment résistants à la maladie.

FERME EXPÉRIMENTALE NORMANDIN

L'espèce *Vicia faba* comme culture spéciale

Adaptation de variétés. La production de gousses vertes de huit variétés de gourgane (*Vicia faba* L. var. *major*) et trois variétés de féverole (*Vicia faba* L. var. *minor* (Peterm.) Beck.) a été comparée en parcelles. Les trois variétés de gourgane: Vainqueur, Rapide et Windsor, ont produit une moyenne de 10 170 kg/ha, soit 526 kg de plus que Erfordia, la meilleure variété de féverole à l'essai.

Dans un autre semis comportant sept variétés de féverole, Erfordia et Hertz Freya ont produit une quantité identique de grains secs, soit 5190 kg/ha; Minden, Côte Sud et Kleine Thuringer ont formé un groupe intermédiaire avec une moyenne de 4418 kg/ha, alors que Ackerperle et Diana n'ont rapporté que 3596 kg.

Écimage de la féverole. La variété Erfordia écimée après 81, 88 et 95 jours de végétation n'a pas subi une diminution sensible de la teneur en humidité, plant entier et gousses, comparativement au témoin intact.

Régie de la gourgane et de la féverole. Deux buttages, effectués au stade de 10 cm et 25 cm de croissance, de la gourgane Grosse de Windsor fertilisée à la volée au semis ont contribué à un accroissement significatif de la production de grain sec (4585 kg/ha) en comparaison de plants buttés une seule fois au stade de 10 cm (4260 kg/ha) et de plants non buttés fertilisés au semis, soit en bande (4253 kg/ha), soit à la volée (3864 kg/ha). La féverole Erfordia n'a pas été influencée par l'un et l'autre traitement et a produit une moyenne de 3708 kg/ha.

On a étudié la réponse de la gourgane Windsor et de la féverole Erfordia à la contrainte imposée par la compétition entre les plants en variant l'écartement des rangs et, par conséquent, la population par unité de surface. La surface de terrain entre les plants a été le facteur critique puisque la diminution du rendement en grain sec a été proportionnelle à l'espace entre les rangs, soit: 5088, 3200, 2545 et 2007 kg/ha avec la gourgane et 3664, 2480, 1695 et 1385 kg/ha avec la féverole, respectivement dans les espacements de 17,5, 35, 52,5 et 70 cm. Le poids sec par plant a été significativement plus élevé avec les plus grands espacements, indiquant ainsi que la croissance végétative s'est faite au détriment de la formation du grain.

L'apport de N aux taux de 28, 56, 84, 112 et 168 kg/ha n'a pas eu d'effet tangible sur la production en grain sec de la féverole Erfordia qui avait reçu une fumure de base faite de 448 kg/ha de 5-20-20. Le rendement moyen a été de 2168 kg/ha dans une population de 366 300 plants/ha.

Exploitation de la féverole comme fourrage. Des parcelles de féverole ont été récoltées après 36, 48 et 55 jours de végétation et une récolte finale a été faite après 122 jours dans le but de mesurer l'aptitude à la repousse de cette plante. La coupe a été effectuée à environ 8 cm de hauteur. Les résultats obtenus ont démontré qu'il y a peu d'avantages à effectuer des prélèvements en cours de croissance et qu'une seule récolte en fin de saison fournit le double (2400 kg/ha) de la matière sèche produite par un régime comportant deux fauches (1190 kg/ha).

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INTRODUCTION

La Station de recherches de Saint-Jean se spécialise dans les domaines des productions fruitières et légumières. Nous fournissons présentement un effort spécial pour résoudre les problèmes économiques de la production de la pomme et essayons d'augmenter la rentabilité des cultures maraîchères en sol organique tout en prévenant, le plus possible, l'affaissement de ces sols.

Ce rapport contient le résultat sommaire de nos recherches. On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport ou des renseignements additionnels en adressant sa demande directement aux chercheurs ou à la Station, comme suit: Station de recherches, Agriculture Canada, Casier postal 457, Saint-Jean, Québec J3B 6Z8.

J. J. Jasmin

Directeur

POMME

Entomologie

Mouche de la pomme. L'émergence des adultes de *Rhagoletis pomonella* (Walsh), qui a débuté le premier juillet et s'est terminée vers la fin d'août, a été un peu moins abondante qu'en 1973.

Punaise terne. Les dégâts causés par *Lygus lineolaris* (P. de B.) ont été un peu moins élevés qu'en 1973. Malgré cela, deux applications de l'un ou l'autre des insecticides DDT, diméthoate, trichlorfon, amidophos, methidathion, formetanate, azinphos-méthyl, phosmet et leptophos n'ont pas réussi à éliminer complètement les dommages.

Charançon de la prune. Deux applications de l'un ou l'autre des produits methidathion, dialifos, azinphos-méthyl, leptophos et parathion-méthyl ont réprimé *Conotrachelus nenuphar* (Hbst.) dans une proportion de 97% à 99%.

Attraction sexuelle. Des phéromones sexuelles synthétiques, employées pour déterminer l'opportunité d'appliquer des traitements insecticides, ont permis d'évaluer les populations de la pyrale de la pomme, *Carpocapsa pomonella* (L.), de la tordeuse à bandes rouges, *Argyrotaenia velutinana* (Wlk.), de la tordeuse à bandes obliques, *Choristoneura rosaceana* (Harr.) et de la petite pyrale de la pomme, *Grapholitha prunivora* (Walsh).

Tétranyque rouge du pommier. Les fongicides bénomyle et Dikar (Rohm & Haas Inc.), tout en réprimant la tavelure, tinrent en échec les populations de *Panonychus ulmi* (Koch) jusqu'à la mi-été, favorisant ainsi une lutte

intégrée. Par ailleurs, carbophénothion-huile s'est avéré aussi efficace qu'éthion-huile en traitement préventif. Dans nos essais de fumigation sur des pommes destinées à l'exportation, le mélange de dibromoéthane et de bromure de méthyle détruisit presque 100% des oeufs.

Phytopathologie

Tavelure du pommier. Dix applications régulières de l'un ou l'autre des produits bénomyle, thiophanate de méthyle, dodine et Dikar ont contrôlé la tavelure, *Venturia inaequalis* (Cke.) Wint., dans une proportion de 93% à 97%. Les nouveaux produits tels que cypendazole, DPX-164 (DuPont of Canada Ltd.) et le mélange bénomyle-manèbe ont également contrôlé la maladie dans une proportion de 93% à 98%. D'autre part, les parcelles traitées avec une dose massive de captafol ont donné autant de fruits sains qu'une parcelle témoin traitée à la dodine.

Génétique

Sélection et cultivars de pommiers. Les pommiers à lambourdes endommagés par le froid sont surtout ceux greffés sur semis de Délicieuse et de McIntosh. Le cultivar «Macspur» demeure plus précoce et plus productif que plusieurs autres sélections.

Développement de porte-greffes. Le système racinaire des porte-greffes M.7, M.4, MM.106, MM.111 et M.26 a été fortement endommagé lors d'un hiver rigoureux sans neige. Les porte-greffes 0-3, 0-5, 0-8, 0-12, M.4 et M.26 favorisent une mise à fruit rapide. D'autre part, 0-3 répond mieux au bouturage des racines que M.7 et *Malus*

robusta 5; un prétraitement de 15 jours sous brouillard favorise l'enracinement.

Régie des pommeraiès

Régulateurs de croissance. Des traitements à l'éthéphon ont augmenté de 20% à 25% le rendement de la Melba. De plus, des applications de ce produit à 100 et 200 ppm avec NAA et 2,4,5-TP à 20 ppm, 2 semaines avant la date normale de cueillette, ont augmenté considérablement la coloration des Melba et avancé la cueillette de 8 à 10 jours.

Herbicides. Excepté pour le dichlobenil, les traitements du printemps furent plus efficaces que ceux d'automne; dichlobenil, terbacil et metribuzin ont facilement détruit toute la végétation.

Atomiseurs. Les pulvérisations concentrées à l'aide d'atomiseurs à prise de pouvoir au tracteur et utilisés à vitesse réduite ont donné des résultats comparables à celles appliquées au moyen d'un pulvérisateur conventionnel. Des essais préliminaires ont démontré que les doses de fongicides à l'acre pourraient être diminuées avec des concentrations de 15 × et plus.

FRAISE

Entomologie

Écologie. L'étude de la faune des fraisières s'est poursuivie au cours de 1974. Les insectes qui ont causé les dommages les plus considérables sont la punaise terne, l'anthonyme de la fleur du fraisier, *Anthonomus signatus* Say, la chrysomèle rhizophage du fraisier, *Paria fragariae* Wilcox, la tordeuse du fraisier, *Ancylys comptana fragariae* (W. & R.) et l'altise à tête rouge, *Systema frontalis* (F.).

Répression. Des essais de répression de la punaise terne dans deux localités différentes du sud-ouest du Québec ont montré que dans un endroit le methidathion s'est avéré le meilleur insecticide tandis que dans l'autre le trichlorfon s'est classé le produit le plus efficace.

Phytopathologie

Blanc du fraisier. La fin d'une série d'essais de fongicides pour le traitement spécifique du blanc du fraisier, *Sphaerotheca humuli* (DC.) Burr., a démontré qu'il n'est pas économique de pratiquer des traitements

spécialement contre cette maladie. Les applications, même chez les cultivars les plus sensibles, comme la Earlidawn, n'ont pas suscité d'augmentation significative dans les rendements.

Génétique

Évaluation des cultivars et sélections de fraisiers. Les dix meilleurs cultivars et sélections à Frelighsburg (Qué.) ont été dans l'ordre décroissant: Catskill, Redgauntlet, Senga Sengana, K-65-72, K-64-403, K-68-408, Veestar, Vibrant, Bounty et Redchief. A La Pocatière (Qué.), les dix meilleurs dans le même ordre ont été: K-64-436, K-68-108, Guardsman, Redcoat, Sparkle, K-64-403, Vibrant, Earlidawn, Veestar et Cavalier.

FRAMBOISE

Entomologie

Écologie. L'étude de la faune dans les framboisières a montré que les insectes les plus ravageurs ont été la punaise terne, les nitidules, *Carpophilus dimidiatus* (F.) et, à la fin de la récolte, l'anneleur du framboisier, *Oberea bimaculata* (Oliv.) et les cynipes (Cynipidae) qui causèrent des galles sur la variété Newburg.

Phytopathologie

Blanc du framboisier. Des essais sur la répression du blanc du framboisier ont démontré qu'il n'était pas avantageux de traiter spécifiquement contre cette maladie. Les traitements avec des mildioucides n'ont pas contribué à augmenter les rendements d'une façon significative même chez les cultivars sensibles comme la Carnival.

MAÏS

Génétique

Résistance à la pyrale du maïs. Sous infestations naturelles et artificielles d'*Ostrinia nubilalis* (Hbn.), 132 hybrides et 131 lignées de maïs grain provenant de 21 centres de maïs à travers le monde ont fait l'objet d'études suivies quant à leur maturité, leur sensibilité aux pontes de l'insecte, leur tolérance ou résistance à la pyrale, ainsi qu'à leur rendement. Bien que l'infestation artificielle fut réduite, 60% des plantes ont démontré une certaine résistance (antibiose) aux premières attaques des jeunes chenilles, mais

plus tard à l'automne, 66% démontraient une sensibilité à l'insecte. Présentement, le meilleur matériel génétique trouvé très résistant à la pyrale provient de variétés synthétiques développées en Iowa et à la Station de recherches d'Ottawa. En fait, dans le cadre d'une coopération internationale en vue de l'amélioration génétique du maïs pour une plus grande résistance à la pyrale, 21 lignées et 43 hybrides simples furent mis à l'essai dans 14 pays. La lignée canadienne C0221 s'est particulièrement révélée résistante à la pyrale et C0114, en croisement avec des lignées hongroises de même maturité, s'est montrée très résistante à la pyrale.

Lutte chimique

Pyrale du maïs. Les essais de lutte chimique contre la pyrale, en plein champ sur maïs sucré et maïs grain, ont comporté l'évaluation d'insecticides granulés, tels que le chlorfenvinphos, fonofos, triazophos, carbofuran, diazinon, leptophos, CME 74210, CME 74200 (EM Laboratories, Inc.), N-N-2596 (Stauffer Chemical Co.), *Bacillus thuringiensis* Berliner et d'insecticides en pulvérisation, le carbaryl et le carbofuran, tous deux présentement homologués au Canada contre la pyrale. Seulement N-2596 a donné de bons résultats quant au nombre d'épis vendables à l'état frais et ce produit ainsi que le chlorfenvinphos ont sensiblement réduit les populations larvaires dans les plantes au moment de la récolte de maïs sucré. Quatorze insecticides furent testés en laboratoire contre des larves de la pyrale; FMC 33297 (FMC of Canada Limited), chlorpyrifos, carbaryl et DDT ont donné de bons résultats contre les chenilles du premier âge, mais seulement FMC 33297 s'est avéré efficace contre les larves du troisième âge ou plus âgées.

Fertilité des sols

Réponse du maïs sucré au phosphore rémanent dans le sol. Les rendements les plus élevés d'épis vendables ont été obtenus l'année de l'application du phosphore. Bien que cet élément possède un fort pouvoir rémanent dans le sol après quelques années de culture, ceci ne semble pas être le cas pour le maïs sucré produit sur un loam argileux de St-Blaise.

CAROTTE

Nématologie

Des six fumigants de sol utilisés au printemps dans la culture de la carotte, le D-D (Shell Canada Ltd.), 402 litres/ha, le Telone C (Dow Chemical of Canada Ltd.), 268 litres/ha et le Vorlex (Morton Chemical Co.), 134 litres/ha ont sensiblement réduit le nombre de nématodes dans le sol après le traitement et, de plus, ils ont donné respectivement, 35,5, 32,1, 27,3 t/ha de carottes vendables et seulement 3,4%, 6,2% et 9,8% de carottes avec nodosités, comparativement au témoin, non traité, 8,0 t/ha et 63,4%.

Production de mini-carottes en sol organique

Étude variétale. Les cultivars Amstel, A.M.C.A., Baby Finger, Amsterdam A.B.K., Amsterdam Mini-Cor, Little Finger et Mini Pak furent semés avec un semoir à cône (trois rangs équidistants de 5 cm) à raison de 1300 plants/m², les 4 et 18 juin et le 15 juillet. A la première récolte (77 jours), le rendement moyen total fut de 22,7 t/ha avec un classement de 56% n^o 1, 23% jumbo et 21% rebut. La deuxième récolte (70 jours) a donné 16,0 t/ha dont 42% n^o 1, 46% jumbo et 12% rebut. Le troisième semis fut détruit à 90% par les inondations et la grêle en juillet. La plupart des variétés ont une très belle forme pour l'emballage en cello sauf Mini Pak dont le diamètre de la couronne (22,6 mm) dépasse les normes et Amsterdam A.B.K. qui est trop longue (99 mm). A la récolte, la hauteur moyenne du feuillage est de 25 cm pour toutes les variétés, sauf Mini Pak qui domine avec 40 cm. Afin d'augmenter le volume de n^o 1 à 16 ou 18 t/ha, on devra améliorer la technique des semis (densité et espacement).

Densité de semis. Cette phase du travail comprend les mêmes cultivars qu'à la section ci-haut mentionnée, mais semés à l'aide d'un semoir Planet Jr modifié pour donner une bande de cinq rangs équidistants de 2,5 cm. En utilisant l'ouverture n^o 9 (taux de semis 7,25 kg/ha), on obtient une augmentation du rendement total et vendable d'environ 10% respectivement et une réduction de 50% du volume jumbo. Au taux de semis de 10,2 kg/ha, on note une réduction du rendement total de 25% pour les variétés Amstel et Baby Finger, une légère réduction dans la classe

jumbo, mais une augmentation du pourcentage de rebut. Avec l'ouverture n° 10, il y a réduction de la longueur moyenne des racines tandis que la couronne atteint le diamètre idéal de 15,3 mm. Afin de remédier au taux élevé de rebut avec cette méthode, on étudiera l'espacement des rangs à 30 cm avec un taux de semis de 7.25 kg/ha.

OIGNON

Phytopathologie

Évaluation des pertes causées par le charbon et la fonte des semis — Epidémiologie et répression. Le Pro-Gro 80D (UniRoyal Chemical Co.) à 25 g/kg, seul ou en mélange avec les fongicides Derosal (Hoechst Chemicals), Truban (Mallinckrodt Chemical Works) et chloroneb a donné une bonne répression du charbon de l'oignon, *Urocystis magica* Pass. ap. Thüm (5% à 10%). Par contre, les mêmes fongicides, sans le Pro-Gro, n'assurent pas une répression adéquate du charbon ($\pm 50\%$).

Une épreuve de résistance au charbon de l'oignon de 30 cultivars semés dans un sol organique inoculé avec une concentration de 10 spores/kg de sol sec a donné les résultats suivants: six cultivars avaient de 10% à 15% de charbon; 13 avaient de 15,1% à 20% de charbon; 9 avaient de 20,1 à 25% de charbon et 2 de 25,1% à 30% de charbon. Il semble qu'aucun cultivar ne soit résistant mais que certains aient plus de tolérance que d'autres. L'essai a aussi démontré que l'infection est proportionnelle à la concentration de spores dans le sol.

Malherbologie

La répression des mauvaises herbes de l'oignon, au moyen des herbicides homologués, s'est avérée inadéquate même en utilisant des programmes d'applications. Certaines combinaisons comprenaient jusqu'à trois produits différents et huit applications. Dans un autre essai, cependant, le nouvel herbicide oxadiazon, appliqué à trois reprises au taux de 0,56 kg/ha ou deux fois à 0,84 kg/ha, a fourni un très bon contrôle des mauvaises herbes. Cet herbicide cause une légère phytotoxicité, surtout à un taux élevé. L'herbicide apparaît donc prometteur surtout à un faible dosage, soit seul ou en mélange avec d'autres produits et à des applications répétées.

Évaluation des variétés

Dix-huit variétés traitées au Pro-Gro furent semées au semoir de précision Stanhay à raison de 66 graines/mètre linéaire. Le pourcentage moyen de survie à 6 semaines est de 44% mais tombe à 33% à la récolte (120 jours). La variété témoin Autumn Spice est très sensible aux fluctuations climatiques et donne le plus faible rendement. Certains hybrides relativement nouveaux, tels que Bronze Age, Fawn Preview et Ontario L, ont un rendement élevé et un faible pourcentage (15%) de rebut. Le rendement total moyen fut de 16,5 t/ha réparti comme suit: 58% n° 1, 21% n° 2 et 21% rebut.

Parmi les 36 cultivars dans l'essai d'introduction, on relève les points suivants: Spartan Sleeper, un nouvel hybride du Michigan, avec 41,4 t/ha est supérieur de 36% à D.Y. Globe, Trapp #8 et Spartan Banner; Ruby, une variété rouge à retenir, donne un rendement total de 38,4 t/ha avec 88% n° 1 et 5% rebut.

CHOU

Génétique

Une épreuve de résistance à la hernie, race 6, fut réalisée en plein champ avec huit lignées issues d'un croisement d'une lignée autofertile \times 8-41. Les lignées 74-07 et 74-08 se sont montrées résistantes. L'indice pathologique était de 1,2 et 4,0 respectivement.

Phytopathologie

A la ferme de L'Acadie (Qué.), deux grandes parcelles furent inoculées artificiellement avec une forte concentration de spores de hernie, *Plasmodiophora brassicae* Wor.: l'une avec la race 6, l'autre avec la race 2. L'inoculation fut réussie à 95%. Ces parcelles serviront dans le futur aux épreuves de résistance des nouvelles lignées.

LAITUE

Rendements par rapport à variétés, semis de précision et maladies

Trois semis de précision avec de la semence enrobée des variétés Minetto, Ithaca, Fulton, Fairton et Imperial 456 et aux distances entre les plants de 25 et 30 cm pour la Minetto et de 30 et 36 cm pour les autres

variétés n'ont pas donné les résultats escomptés à cause de conditions climatiques défavorables au cours de la saison 1974. La germination du premier semis a varié de 85% à 68%, tandis que celle du deuxième semis a été en moyenne de 22% inférieure. L'application d'un engrais chimique commercial augmente les rendements mais seul l'azote est responsable de cette augmentation.

Le mélange sulfallate-paraquat utilisé pour la destruction des mauvaises herbes, selon la méthode des semis différés, donne de bons résultats et facilite les sarclages manuels. Des six fumigants de sol utilisés pour le contrôle des nématodes dans la culture de la laitue, le Telone C, 268 litres/ha, a donné les meilleurs résultats.

Une enquête menée chez 10 producteurs a démontré que les pertes dues aux maladies et autres facteurs s'élèvent à 20% (pourriture basale, 7%; jaunisse, affaissement sclérotique, mosaïque, 6%; pommes molles, etc., 7%). On a observé le puceron de la racine, *Pemphigus bursarius* (L.), dans six champs et la nodosité, *Meloidogyne hapla* Chitwood, dans quatre champs sur 10.

GESTION DES SOLS ORGANIQUES

En 1974, on a entrepris des recherches portant sur la gestion et la préservation des sols organiques utilisés à la production maraîchère.

Affaissement des sols organiques

Facteurs hydrologiques. La ferme expérimentale de Ste-Clothilde, Québec fut arpentée en 1942. Après 32 ans, un arpentage systématique du terrain a permis de déterminer un affaissement maximal de 0,787 m dans certains cas. Des puits d'observations furent installés dans le but de suivre les mouvements de la table d'eau et il semble probable que le niveau trop bas de cette table serait l'une des causes principales de l'affaissement des sols. L'érosion de ces sols, qui ont une très faible pente, ainsi que des inondations locales sont cependant possibles durant de fortes précipitations lorsque le taux de

percolation trop bas ne permet pas la pénétration de cet excès d'eau dans le sol.

Production de CO₂. Dans des conditions de laboratoire, la respiration d'un sol organique incubé à 200% d'humidité démontre qu'il faudrait 90 ans pour perdre 453,6 t de sol organique par simple oxydation.

Rémanence et disponibilité du potassium

De tous les éléments nutritifs nécessaires à la production des légumes en sol organique, le potassium est le premier à manquer dans des conditions de culture intensive. Le potassium résiduel n'est pas absorbé par la carotte, ce qui indiquerait qu'il est, soit non assimilable, soit lavé, ou, peut-être un peu des deux.

Transformation de l'azote

Des sols organiques exposés à différents régimes de culture et de fumure furent échantillonnés à tous les 20 cm sur une profondeur totale de 100 cm durant la saison de croissance. A chaque endroit, le NH₄-N était présent en plus grande quantité que le NO₃-N et restait stable durant toute la saison. NO₃-N a atteint un maximum en août puis a décru. L'azote inorganique dans le sol n'a jamais dépassé 100 ppm de N, ce qui suggère fortement le besoin d'un apport de fumure azotée pour permettre une récolte maximale.

Les antiparasitaires en sol organique

Dans les conditions normales de champ, le linuron appliqué à la volée au taux de 4,48 kg/ha a été retrouvé presque au complet par nos analyses après un mois. Trois mois après l'application, les racines ainsi que les feuilles de carottes ne contiennent aucune trace de linuron. Les possibilités de métabolites à l'intérieur des tissus de la carotte sont à l'étude.

L'effet du linuron, du carbofuran, du fonofos et du paraquat sur la microfaune du sol a été étudié. Un effet synergétique du linuron et du carbofuran sur la microfaune demande des études plus poussées. Les transformations d'azote et de phosphore, influencées par la microfaune, ont nécessairement fluctué sensiblement.

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Research Station Delhi, Ontario

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¹Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station at Delhi is located in the heart of the largest flue-cured tobacco area in Ontario, where over 72% of the crop is grown within a radius of 32 km (20 miles). Emphasis is placed on the production and health programs, done in cooperation with the Department of National Health and Welfare and the Universities of Guelph, Waterloo, and Kentucky.

This report summarizes the main accomplishments of 1974. Detailed information may be obtained from individual scientists. Correspondence should be addressed to: Research Station, Research Branch, Agriculture Canada, Delhi, Ont. N4B 2W9.

L. S. Vickery
Director

SOIL SCIENCE

Potassium Depletion

Seven consecutive crops of flue-cured tobacco were grown in a Fox loamy sand with K omitted from the fertilizer. The level of K in the soil was less than half of that in soil fertilized with K at 17.8 kg/ha. Omission of K from the fertilizer lowered the K in the leaves but increased P, Ca, and Mg. Lamina weight, particularly of leaves from the middle and lower stalk positions, was high. Cigarettes from K-depleted tobacco had poor burning qualities, but total particulate matter in the smoke was unaffected. Low concentrations of total alkaloids were found in these leaves, but levels found in the smoke were similar to those of K-fertilized tobacco.

Side-dressing

Application of fertilizer (3-9-21 or 3-16-18 analysis) at 336 kg/ha 3-4 wk after the tobacco plants were transplanted increased the annual yield from 1970 to 1974 by 56-258 kg/ha; the greatest response to treatment was in 1972 when excessive rainfall in June leached soil nutrients from the root zone.

Nematocides

Control of the root-lesion nematode *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. in soil in which tobacco had been recently transplanted was better with fumigants than with nonfumigants. Both types of nematocides produced similar control in the roots. Final yields of flue-cured tobacco could not be correlated with the degree of control of *P. penetrans* at any one time during the growing season. The fumigants studied were D-D,

dichloropropene, chloropicrin, and Vorlex. Oxamyl and ethoprophos were the nonfumigants investigated.

PLANT SCIENCE

Time of Topping

Topping during the prebud and bud stages of growth gave higher yields over 3 yr than did topping at both the normal stage, when three flowers are fully open, and the late stage. Levels of total alkaloids in leaves and in smoke were highest when topping was done during the prebud and bud stages and lowest when the tobacco was not topped. Topping during the prebud stage tended to give the highest levels of total particulate matter in the smoke.

Ethephon

Acceleration of ripening upon application of ethephon increased with age and maturity of the leaves. Maximum response occurred when the chemical was applied after the time of normal harvest. Response also increased with rate of application, up to 150 mg per plant. Immature upper leaves were unaffected by ethephon. Relatively ripe upper leaves were affected by treatment. When these leaves were cured, the extent of quality deterioration was less than that of treated leaves from the middle and lower stalk positions. Ethephon was effective in producing desirable overripeness in leaves of dense populations designated for whole-plant harvest within 4 days of application. However, leaf drop became increasingly pronounced when harvest was delayed beyond 4 days.

Culture for Whole-plant Harvest

Yield increased with population among densities of 16 400, 27 000, 40 400, 60 800, and 80 900 plants/ha (6,650, 10,917, 16,376, 24,624 and 32,750 plants/ac). Levels of starch varied little with population: 3–4% starch was measured in whole plants compared with about 1.5% in whole leaves or in stalks only. Yield also increased with each 672-kg increment of fertilizer broadcast between 1008 and 2352 kg/ha. Measured brightness of chopped whole plant, particularly of plants fertilized at 1008 kg/ha, was similar to that of high-quality grades of whole leaves.

Harvesting and Curing of Whole Plants

A harvesting-curing-handling system for whole plants was developed in conjunction with the Engineering Research Service. A forage harvester was modified and boxes were designed for collecting and curing chopped material. Bulk kilns were adapted for curing, and an apparatus was designed to unload the boxes.

PLANT PHYSIOLOGY

DDT

Levels of DDT in cured tobacco were monitored on 32 farms in the tobacco-growing region. The study was started in 1971 after the use of various chlorinated hydrocarbons was restricted. In 1971 the average total DDT content (*o,p'*-DDT, *p,p'*-DDT, *p,p'*-DDE, and *p,p'*-TDE) was 1.29 ppm, with a range of 0.38–2.28 ppm. Average values for the 1972 and 1973 crops were 0.78 and 0.84 ppm, with ranges of 0.31–1.52 ppm and 0.35–1.65 ppm, respectively.

The study showed a general decrease in DDT levels with time, especially from 1971 to 1972. Because approximately 80% of the total DDT available to the plants was bound in the roots, most of the chlorinated hydrocarbon was returned to the soil.

Formulation of Sucker-control Chemicals

A study was undertaken to vary levels of surfactant (Tween 80) in a sucker-control formulation in which *n*-decanol was the active ingredient. Surfactant levels were 50, 100, and 150% of that in commercial formulations.

The effects of surfactant applied at these levels without the active ingredient were identical with those of water. Total alkaloids, reducing sugars, lamina weight, filling value, and yield were similar. The effects of commercial formulations were similar to those of the experimental formulations that contained *n*-decanol combined with varying levels of surfactant. The use of sucker-control chemicals resulted in highly significant increases in reducing sugars, lamina weight, and yields. The study to date indicates that Tween 80, a common surfactant used in commercial sucker-control formulations, does not adversely affect the physiology of tobacco or reduce the quality of the cured lamina.

Leaf Ripeness

The effects of the degree of leaf ripeness over a 2-wk harvest period were studied. For the variety Delhi 34, increases with ripeness in 3-yr averages for yield, return index, lamina weight, and reducing sugars were highly significant. Highly significant decreases were observed in averages for filling value, total nitrogen, and total chlorophyll. The following factors were unaffected by the degree of leaf ripeness: cured-leaf grade index, total alkaloids, and lignin; smoke tar, nicotine, and tar-to-nicotine ratio; and cigarette puff number, weight, and pressure drop. For the variety Virginia 115, increases with ripeness in 2-yr averages for yield, return index, lamina weight, and reducing sugars were highly significant. Highly significant decreases were observed in averages for grade index and filling value. The degree of leaf ripeness had no effect on averages for green tissue starch, cured leaf total alkaloids, smoke tar_{wet}, nicotine, and tar_{wet}-to-nicotine ratio.

Bioassay Program

The potency of water-soluble smoke condensates from two flue-cured varieties that produce 25 and 23 mg smoke tar per cigarette was tested by doing a short-term bioassay for ciliostasis in tracheal sections from hamsters. Whole-smoke condensates from the same varieties were tested by means of a bioassay for sebaceous gland suppression and epidermal hyperplasia in mice. In both tests the potencies of the two varieties grown the same year were not significantly different, although potencies differed significantly between years.

GENETICS AND PLANT BREEDING

Male Sterile Tobacco Varieties

Cytoplasmic male sterility has been transferred to the commercial flue-cured varieties Delhi 34 and Virginia 115 by a backcross-breeding program. After six backcrosses and selection for either Delhi 34 or Virginia 115 type, the morphological characteristics of the male sterile lines very closely resembled those of their male fertile parents. Field testing for 3 yr has indicated that the sterility characteristics result in a significant reduction in yield, 2-4 days later flowering, lower tolerance for black root rot, higher tolerance for weather fleck, and higher stem content. The usefulness of these lines in the production of F_1 hybrid flue-cured tobaccos would be dependent on the genetic diversity of the other parent in the hybrid for the expression of heterosis.

F_1 Hybrid Tobacco Studies

F_1 hybrids between Canadian and U.S. flue-cured tobacco varieties were evaluated over a 2- or 3-yr period. The agronomic characters of yield, grade quality, leaf number, and leaf size of the hybrids were found to be intermediate. Total alkaloid levels of the F_1 hybrids varied between that of the mean and the lower parent, whereas the reducing sugar content tended to be similar to or less than that of the lower parent. The number of days from transplanting to flowering for F_1 hybrids approached that of the later-flowering parent. Production of ground suckers by F_1 hybrids equaled that of the maximum parent for those varieties studied. Filling value and lamina weight of the cured leaf of the F_1 hybrids were usually greater than those of the midparent. F_1 hybrids in which one parent carried the black root rot immunity factor from *Nicotiana debneyi* Domin. expressed hybrid vigor for most agronomic characters, except for the quality. This character was similar to the midparent value.

PLANT PATHOLOGY

Black Root Rot

When chlorogenic acid was incorporated up to 100 ppm in synthetic media, it had no effect on the growth or sporulation of *Thielaviopsis basicola* (Berk. & Br.) Ferr. A solution of 1000 ppm chlorogenic acid in water significantly reduced the percentage of the endoconidia and the length of germ tubes.

Tobacco leaf disks infected with *T. basicola* endoconidia were floated either on water or on a solution of 100 ppm chlorogenic acid. The number and size of necrotic lesions formed on each disk were similar in both treatments.

Volatile chemical compounds formed during the decomposition of tobacco, rye, and corn residues had no appreciable effect on the growth and sporulation of *T. basicola*.

In field experiments, Banrot (15% terrazole and 25% thiophanate-methyl) at concentrations of up to 250 ppm of the active ingredients (ai) in the planting water had no effect on black root rot severity. Benomyl and thiophanate-methyl at 500 ppm reduced root lesions by 30%, but the vigor of treated and untreated plants was similar. The addition of phosphoric acid to the planting water at a rate of 0.26% did not increase the effectiveness of the systemic fungicides in controlling the disease.

Damping-off

In laboratory tests, growth of *Rhizoctonia solani* Kühn in muck exposed to steam was consistently lower than that in unsteamed muck. The growth of *Phythium ultimum* Trow was similar in both cases.

A mixture of benomyl and captan at 7 g ai/10 m² checked the growth of *R. solani* and *P. ultimum* and effectively reduced the incidence of damping-off. The treatment did not adversely affect seedling growth and subsequent growth in the field, or yield and quality of tobacco.

Pole Rot

Rhizopus arrhizus Fischer grew more vigorously on synthetic media containing starch than it did on those containing maltose or glucose as a carbon source.

Preharvest spraying of tobacco with 100 ppm of either quintozene or formalin (37% formaldehyde) in water reduced subsequent

infection with pole rot by 30–50%. When the twine used to tie tobacco leaves to the lath was treated with quintozene or dichloran, tobacco leaves were partly protected against pole rot infection; levels of dichloran residues in the cured leaf were approximately 7 ppm.

Forced-air circulation during fumigation of tobacco leaves with tecnazene effectively reduced infection with pole rot. Smoke quality of the cured leaves was acceptable, and residues were only 0.5 ppm.

ENTOMOLOGY

Cutworms

The effect of soil moisture on toxicity of chlorpyrifos and leptophos against the fifth- and sixth-instar larvae of the darksided cutworm was studied. Both materials were significantly more active in moist soil than in dry soil and showed a regular trend for

mortality increases with increase in moisture content.

Nine chemicals were tested in a field for their effectiveness as postplanting treatments for control of the darksided cutworm on tobacco. Leptophos and N-2596 best controlled the larvae of this pest; carbaryl, acephate, and trichlorfon showed similar degrees of effectiveness. Temephos and methidathion were numerically less effective than carbaryl and trichlorfon, which are currently recommended as a postplanting treatment to control cutworms. Chlordimeform and PP-505 were ineffective at the rate applied. All materials tested caused no visible phytotoxicity to the tobacco plants.

Aphids

Greenhouse and field-trial data indicated that a single application of oxydemeton-methyl to tobacco plants provided excellent control of the green peach aphid, for at least 5 wk.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	Manufacturer
Banrot	Mallinckrodt Chemical Works
D-D Soil Fumigant	Shell Canada
N-2596	Stauffer Chemical Company
PP-505	Chipman Chemical Co.
Tween 80	ICI United States Inc.
Vorlex	Nor-Am Agricultural Products Ltd.

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Research Station Harrow, Ontario

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W. G. BONN, B.Sc., M.S., Ph.D.	Bacterial diseases
B. N. DHANVANTARI, ¹ B.Sc., M.Sc., Ph.D.	Tree fruit diseases
L. F. GATES, B.A., Ph.D.	Cereal viruses and corn diseases
J. H. HAAS, B.S., Ph.D.	Soybean and white bean diseases
P. W. JOHNSON, B.S.A., M.Sc., Ph.D.	Plant parasitic nematodes

Soil Substation, Woodslee, Ontario

J. W. AYLESWORTH, B.S.A., M.S., Ph.D.	Officer in Charge
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Departure

W. A. SCOTT, B.S.A. Retired December 30, 1974	Burley tobacco management
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EXTENSION SERVICES²

J. C. FISHER, B.S.A.	Greenhouse and vegetable crops
K. H. FISHER (Miss), B.Sc. (Agr.), M.Sc.	Fruit and vegetable crops

¹On a transfer of work from August 19, 1974 to August 4, 1975 at the Department of Scientific and Industrial Research, Auckland, New Zealand.

²Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

Research programs at the Research Station at Harrow involve field and greenhouse vegetable production, corn, soybeans, field beans, soft white winter wheat, and tree fruit production. The plant breeding programs resulted in the release in 1974 of two new nectarine cultivars, a new soybean cultivar, and two new corn hybrids. Programs on disease, insect and weed control, and crop management have produced modified and improved production practices for the above crops.

This report deals with some of the highlights of the results of research in 1974. Requests for reprints or for further information should be addressed to: Research Station, Research Branch, Canada Department of Agriculture, Harrow, Ont. N0R 1G0.

G. C. Russell
Director

FIELD CROPS

Cereals and Forages

Viruses. Wheat spindle streak mosaic appears best controlled by resistant cultivars. The reactions of 344 wheat genotypes and wheat-rye crosses were tested in the field; the 35 lines selected overwintered well and showed no sign, or only occasional signs, of the disease. Seed from crosses made in 1973 between the resistant cultivar Halytchanka and three susceptible commercial cultivars gave susceptible plants, which demonstrates that resistance depends on recessive factors.

In alfalfa seed obtained locally, usually about 1.5% of the seeds were infected with alfalfa mosaic virus.

Corn

Breeding. Production rights to two Harrow corn hybrids involving Harrow inbreds were granted to two commercial companies. One will be marketed as Co-op 320 and the other as Pickseed 185. One Harrow inbred, CH 9, has been used extensively over the past decade by private and public breeders as a source of germplasm for new inbred lines because of its resistance to stalk rot and the European corn borer as well as its good combining ability.

Herbicide leaching. Tile runoff water from corn plots monitored at Woodslee in 1974 contained atrazine levels of 20–30 ppb, a significant increase over the levels found in the 3 previous years.

Insects. All stages of the northern corn rootworm, *Diabrotica longicornis* (Say), were at low population densities in 1973 and 1974 and yield reductions in corn were negligible.

The mean densities were: overwintered eggs, 4.1/1000 g of soil; larvae, 3.2/plant; and adults, 1.2/plant. The effect of reducing the use of soil insecticides is under investigation.

The second brood of a bivoltine strain of the European corn borer was of much greater importance than the first brood in 1973. Only 24 of 160 untreated plants examined had first-brood egg masses, although 111 of these plants were eventually fed upon by first-brood larvae, whereas 140 of 160 plants had second-brood egg masses and nearly every plant was eventually damaged by borers. When average yields were calculated it was found that control of both broods or the second brood only produced significantly greater yields than those obtained from untreated plots. There was no increase in yield when just the first brood was controlled.

Leaf spot. Numerous water-soaked spots, which become dry and brown, and then white, sometimes appear on corn leaves. This condition is seed-transmitted and appears to be genetic in origin or genetically controlled.

Movement of nitrate-N in sandy soils. Downward movement of $\text{NO}_3\text{-N}$ in sandy soil was slower than expected. Ceramic tensiometers, placed at depths of 0.6, 1.2, 1.8, 2.4, 3.0, and 3.7 m (2–12 ft) in the soil, were evacuated weekly to obtain samples of water from the soil profile. Where an application of N at 560 kg/ha was made in June 1973, $\text{NO}_3\text{-N}$ moved below the 0.6-m (2-ft) depth in late November, below the 1.2-m (4-ft) depth in February, and below the 1.8-m (6-ft) depth in March, after which downward movement appeared to cease. No significant concentration of $\text{NO}_3\text{-N}$ was detected in the

groundwater. This may be because of dilution or possibly denitrification. During the latter part of the period, when rainfall was less than normal, the water table fell from a depth of 2.7 m (9 ft) in 1973 to a depth of 4.1 m (13.5 ft) in October 1974.

Root and stalk rot. Ear weights of the susceptible cultivars Pioneer 3773 and Co-op 335 at silking and 1, 2, and 3 wk later were 70, 53, 40, and 33% greater than the ear weights of the resistant cultivars Harrow 73 and B 14 \times CH 9 at these times. In some hybrids, rapid ear development may accentuate early deterioration of the stem pith through competition for nutrients.

Tile drainage for corn. Tile installation at a 60-cm depth on Brookston clay soil increased corn yield by 628 kg/ha over yields where the installation was at 107 cm. Tile lines spaced at intervals of 18.3, 36.6, and 73.2 m produced corn yields of 6020, 5630, and 4530 kg/ha, respectively, indicating considerable benefit from tile drainage on clay soil even during a rather dry season.

Weed control. Competition from a mixture of weed species was most critical during the 2nd to 4th wk after corn germination. Weed control in this period ensures maximum yields. A postemergence herbicide application 6 wk after germination did not kill all weeds but resulted in increased corn yields.

A computer-based system has been developed for storage and retrieval of weed control research data recorded in the corn and soybean sections of the Canada Weed Committee Research Reports (Eastern Section) for 1969–73. The system is flexible and can be expanded or duplicated. It provides information on herbicides applied individually or in combination, at various rates, on different soil types, and for individual weed species.

Soybeans

Breeding. Harlon, a new cultivar developed at the Station, was licensed and released to seed growers in 1974. In 13 tests in southwestern Ontario during 1971–74, Harlon matured 3 days earlier and produced a 4% higher yield than Steele. Harlon is resistant to races 1 and 2 of *Phytophthora megasperma* Drechs. var. *sojae* Hildebrand.

Pathology. Isolates of *P. megasperma* var. *sojae* obtained from soybean fields in Essex County were found to be different from races

1, 2, 3, and 4 and have been proposed as races 5 and 6. All currently recommended cultivars for Ontario are susceptible to races 3, 4, 5, and 6. Germplasm was screened and the cultivars Kingwa, Toyosuzu, and Tracy were found to be resistant to all six races.

Physiology. It has been established that certain flavonol glycoside genes are associated with reduced chlorophyll content and reduced photosynthetic rate. This correlation between chlorophyll level and photosynthetic rate was shown to be a more general phenomenon than it was previously thought to be. It was observed in experiments with 48 cultivars of diverse backgrounds, grown both in the field and in the growth chamber.

Weed control. Excellent control of velvetleaf in soybeans has been obtained with metribuzin and bentazon. Over a 4-yr period soybeans showed a wide variation in tolerance for atrazine incorporated in soil at levels from 0.275 to 2.2 kg/ha (0.25 to 2.0 lb/ac), which indicates the important influence of seasonal factors. The application of triazine herbicides at rates up to 4.4 kg/ha (4 lb/ac) for weed control in corn on a clay loam soil did not affect soybeans planted the following year.

White Beans

Breeding. Total protein content in 912 plant introduction (P.I.) lines of *Phaseolus vulgaris* L. ranged from 15.0 to 35.0%, compared with an average level of 23.7% protein in the cultivar Kentwood. Of the above P.I. lines, 9.6% contained 30% or more protein. Most of the lines were vine types and extremely late, only eight maturing before the frost on September 23, 1974. Lines with desirable agronomic characteristics and high protein will be used in developing cultivars with improved protein content.

Pathology. Plant-pathogenic bacteria were tightly adsorbed to leaf surfaces but could cause infections if the leaves were injured. Populations decreased 10-fold during 6 dry days after inoculation. Keeping the leaves wet after inoculation markedly decreased the number of bacteria that survived; also, 6–12 h of wetness before inoculation was deleterious to the pathogen. Water washings from dry leaves with lesions had relatively low pathogen populations. Numbers of pathogenic bacteria increased during the first 12 h after wetting but very few were found after

24 h of wetness, although many nonpathogenic bacteria were present. Field studies with common and fuscous bacterial blight of white bean showed that the reported greater virulence of *Xanthomonas phaseoli* var. *fuscans* (Burkh.) Starr & Burkh. was not caused by more rapid spread from infected plants; when started by equivalent infection foci, common blight developed faster than fuscous blight.

HORTICULTURAL CROPS

Field Vegetables

Broccoli, Brussels Sprouts, and Cauliflower

Insect control. Weekly sprays of methomyl at 0.56 kg/ha or leptophos at either 0.84 or 1.12 kg/ha effectively controlled leaf-feeding pests on fall crops. Leptophos was more effective than methomyl against thrips.

Cabbage

Insect control by pathogens. Mixtures of formulations of the bacterium *Bacillus thuringiensis* Berliner and chlordimeform (Fundal or Galecron) were applied at half-rates to cabbage in a plot test. The mixtures were as effective against the cabbage looper and imported cabbageworm as the materials used alone at full rates. This suggests an effective method of reducing the quantity of chemical insecticide applied to the crop for insect control.

Cabbage looper virus propagated in cell culture was nearly as effective as virus produced in live insects for control of the cabbage looper.

The bacterium *B. thuringiensis*, the nuclear-polyhedrosis virus of the cabbage looper, and the granulosus virus of the imported cabbageworm were inactivated at similar rates after application to cabbage in the field. Because virus produced in insects killed by the treatment recontaminates leaves, applications of viruses protect the crop for a longer period than do applications of the bacterium or chemical insecticides.

Cucumber

Breeding, testing, and management. It is important that new white-spined pickling types being selected for tolerance for angular leaf spot, *Pseudomonas lachrymans* (Sm. & Bryan) Carsner, also have tolerance for

cucumber mosaic virus (CMV). At Harrow, several vegetatively propagated field selections died, were stunted, or later showed typical CMV mottle. The cuttings were from plants that appeared healthy but later showed CMV symptoms.

Skin color in Ottawa 50 with the rare combination of ivory skin and black spine and in the cultivar White Wonder was shown to be controlled by the same gene.

At a high planting density for machine harvest, white-spined cultivars significantly outyielded black-spined ones. This confirms the importance of developing new white-spined types.

Disease control. Benomyl and thiophanate-methyl reduced the incidence of powdery mildew and increased the marketable yield by about half.

Irrigation. Application of irrigation water to pickling cucumbers grown with 123, 165, or 247 thousand plants/ha and harvested only once (simulated machine harvest) more than doubled yields. Where the crop was grown with 49 000 plants/ha and harvested several times, irrigation tripled the yield. Without irrigation and at 247 000 plants/ha, 33.8% of the total production was culls (nubbins, crooks, wasps) compared with 17.4% at 49 000 plants/ha. Irrigation reduced the percentage of culls to very low values at all populations tested.

Onion

Disease control. A single post-harvest application of benomyl in the windrow improved the marketable yield of Spanish onions stored for 8 wk by about 30% and reduced the incidence of neck rot from 16 to 11%.

Potatoes

Insect control. The systemic insecticide carbofuran, used for control of the Colorado potato beetle, was more effective applied as a single granular treatment when potatoes were planted than as three sprays applied when needed. The carbofuran sprays were better than azinphos-methyl sprays. The granular treatment outyielded the sprays by 10 and 30%, respectively.

Verticillium wilt. Some evidence, to be confirmed, suggests that races of seed-borne *Verticillium albo-atrum* Reinke & Berth. are

specific to the cultivars Irish Cobbler, Superior, Onaway, and Kennebec.

Sweet Corn

Disease control. Applications of the fungicides Banrot (Mallinckrodt) and Dexon (Bayer AG) improved the emergence of sweet corn by 30%, but not the emergence of peas; the latter suffered some phytotoxicity from several fungicides, especially Truban (Mallinckrodt) and chloroneb.

Oviposition by the European corn borer. Counts of moths of both sexes in light traps has proved to be adequately correlated with the number of egg masses deposited on sweet corn plants. Dissection of females to estimate the percentage that had laid eggs did not provide a better estimate of oviposition. There was no dispersal period before mating and egg laying, and less than 42% of the females caught in light traps were virgin, even when flights had just commenced. Three generations occurred at Harrow, associated with flights of new virgin females in early June, late July, and September. Laboratory work showed that the age of females could be estimated from the color and condition of the reproductive organs; according to this method, most females caught in the light trap in 1974 appeared to be less than 2 days old, whereas those caught by sweeping in weeds were older.

Tomatoes

Black plastic mulch. As in a previous test with transplants of processing tomatoes, black plastic mulch placed between rows was slightly more effective in increasing yield than mulch placed over the row. A yield of 59.6 t/ha was obtained where mulch was placed between rows, compared with 55.2 t/ha where mulch was placed over the row. Mulch over the row resulted in yields approximately 9 t/ha greater than those of the unmulched control.

Disease control. Defoliation of field tomatoes resulting from early blight and leaf spot was reduced by 30–50% by the fungicides chlorothalonil, captafol, Zincofol (Chevron Chemical Co.), mancozeb, and triforine.

Growth regulator. When applied as a foliar spray at 0.561 kg/ha, ethephon was shown to be most effective at day temperatures of 21–24°C in speeding up maturity and increasing yields of processing tomatoes. In 1972, the

greatest increase was 31.36 t/ha or 90% over the control; in 1974, the increase was 44.14 t/ha or 108%. In 1973, when temperatures ranged from 29.5° to 33°C, ethephon did not accelerate ripening or increase yields.

Insecticide residues. Residues of malathion and diazinon, insecticides used to control nitidulid beetles, were determined in field tomatoes and canned tomato products. The data obtained showed that the amounts of residue present were well within the tolerance levels set by the Food and Drug Directorate.

Insects. The relative attractiveness to nitidulid beetles (mainly *Glischrochilus quadrisignatus* (Say)) of tomatoes that had been damaged for 1, 2, or 3 days was examined through the release of beetles colored with fluorescent dyes. An average of 51.7% of the beetles recaptured within a few hours of release went to the 3-day-old tomatoes, 32.5% went to the 2-day-old fruits, and only 15.8% went to the 1-day-old fruits. These results emphasize the importance of picking tomatoes as close as possible to the scheduled time for delivery to the factory.

Weed control. Metribuzin applied postemergence after 2 or 3 days of poor growing conditions caused slight temporary injury. The combination of a preplant-incorporated herbicide with a postemergence application of metribuzin continued to provide excellent control.

Greenhouse Vegetables

Cucumber

Protection of bees in cucumber greenhouses. An insulated box has been designed and tested for a hive of bees, to protect them from summer heat in a greenhouse. It is highly recommended by a local beekeeper as a means of reducing the casualty rate of colonies rented to greenhouse cucumber growers. The box can also be used for confining bees during pesticide spraying operations, which makes it unnecessary to remove the hive from the greenhouse.

Breeding and testing. Breeder seed of the parent inbreds of Harrow HG70.72 seedless cucumber was produced. HG70.72 has intermediate length, 60% of its fruits averaging 30.5–35.6 cm. In several trials across Canada, it was comparable in productivity to the

cultivar Toska 70 in both numbers and weight of fruit.

Out of 20 European seedless cucumber cultivars, none has acceptable tolerance for local isolates of cucumber mosaic virus. Harrow inbreds of the European type were crossed with virus-tolerant Harrow 72-1, a line derived from the U.S. Department of Agriculture accession P.I. 105340.

Powdery mildew. The organism that commonly affects crops in the Harrow area was found to be *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll. rather than *Erysiphe cichoracearum* DC. ex M érat.

Tomatoes

Cage plants. A study continued on the effect of light as the principal limiting factor in plant growth in the greenhouse. Six cage plants (procedure described in 1973 Report) of the cultivar Vendor were grown in the spring crop in peat-vermiculite beds and spaced at 2.48 m²/plant. Standard spacing is 0.37 m²/plant. Fruit yield varied from 32.0 to 45.9 kg/plant, depending on the proximity of the plant to the outside glass of the greenhouse. The control plots at standard spacing yielded 14.9 kg/m². This confirms the proposition that, although fruit yield can be greatly varied by altering plant spacing and other related cultural practices, the yield per unit area remains fairly uniform and is determined by the amount of incident light if all other environmental factors are equal.

Delayed planting. The conventional spring cropping period for greenhouse tomatoes in Ontario is January 15 to July 15. Some growers delay planting to economize on fuel and for other reasons. A test to determine the amount of yield reduction in Vendor because of delayed planting of 1 mo and 2 mo produced the following yields: 6 mo, 5.59 kg/plant; 5 mo, 4.60 kg; and 4 mo, 3.91 kg. The average size of marketable fruit increased with each period of delayed planting: 6 mo, 98 g; 5 mo, 110 g; and 4 mo, 119 g.

Disease control. Isolates of *Sphaerotheca pannosa* (Wallr. ex Fr.) L év. and *Botrytis cinerea* Pers., which were tolerant of benomyl at concentrations in excess of field rates, were obtained from roses near the Station at Harrow. The tolerant isolate of *B. cinerea* also showed some tolerance for chlorothalonil, ferbam, COCS, captan, anilazine, and

dichloran, but not for Dikar (Rohm & Haas Co.). Benomyl-tolerant isolates of *B. cinerea* were also obtained from greenhouse tomatoes.

Foot and root rot. A serious and widespread outbreak occurred in the Leamington area of southwestern Ontario and was caused by *Fusarium oxysporum* Schlecht. The soil-borne pathogen is dispersed by water along the ground bed rows from sporulating hypocotyl lesions; it is not eradicated from the soil by sheet steaming at depths greater than 30–40 cm, but tile steaming seems more effective.

Leafminer ecology. Some progress was made in determining the life cycle of the vegetable leafminer. Cage studies demonstrated a wide range of hosts, but in the field it was found only in tomato leaves and several weeds. Many fall tomato crops in the greenhouse were infested, and lettuce was recorded as a new host. The primary parasite *Diglyphus begini* (Ashmead) was recovered from field collections of mined leaves.

Nematodes. High rates of D-D Soil Fumigant (Shell Canada) and split-depth applications controlled the ground bed populations of *Meloidogyne incognita* (Kofoid & White) Chitwood at greater depths than standard rates of D-D, but despite this, only one crop was adequately protected from yield loss. Nematodes rapidly reinfested the soil, though once the crop was established their numbers had little effect on yield. However, they became sufficiently numerous in the top 15 cm to damage a second crop severely.

Foliar application of an experimental systemic nematocide is showing some promise as an alternative control; further studies are also proceeding with the nematocide used in combination with normal fumigants.

Aldicarb in greenhouse soil controlled *Pratylenchus penetrans* (Cobb) Filipjev & Stekh., but residues in rose leaves 25–74 days after application ranged from 0.7 to 11.0 ppm. This demonstrates its prolonged, continuous uptake from the soil and emphasizes the potential residue danger if used before or during vegetable production.

Tree Fruits

Apricots

Breeding. Haggith was introduced as a promising seedling rootstock for apricots. It originated as a chance seedling in Essex County and it was introduced because the seed tree was unusually cold-hardy, consistently productive, and disease-tolerant. The seeds germinated readily and the seedlings, which were adapted to fall planting or spring transplanting, produced uniform stands of budable trees by August. Controlled freezing tests showed that the root systems of Haggith seedlings were more cold-hardy than other apricot seedling rootstocks in common commercial use. Seeds and scion wood of Haggith are available from the Western Ontario Fruit Testing Association, Harrow, Ont.

Nectarines

Breeding. Two cold-hardy nectarines named Harko and Hardired were introduced, the first to come from the Harrow breeding program. Both cultivars were selected from the same progeny (Lexington \times NJN32). Harko ripened 4 days after Redhaven peach and Hardired ripened 5 days after Harko. The fruits of both cultivars were similar in appearance and quality, being yellow-fleshed freestones with attractive, bright red skin. In addition to being superior in cold hardiness to the cultivars from New Jersey, Virginia, and California in the Harrow collection, they also had greater tolerance for bacterial spot caused by *Xanthomonas pruni* (E.F.Sm.) Dowson, and to brown rot caused by *Monilinia fructicola* (Wint.) Honey. Scion wood and trees of Harko and Hardired are available from the Western Ontario Fruit Testing Association, Harrow, Ont.

Peaches

Breeding. Ten promising selections were made from third-generation backcross derivatives in which hardy selections of peach from northern China were used as the source of extreme cold hardiness and several North American cultivars were used as the source of size, appearance, and quality. Some of these selections were comparable with commercially important cultivars but are expected to be significantly more cold-hardy. Progress was made in breeding for improved flesh firmness; several freestone selections were made from progenies in which H523 was

used as the parental source of flesh firmness. New cultivars with very firm and slowly oxidizing flesh will be needed if peaches are harvested and handled mechanically in bulk in the future.

Herbicide residues. Accumulation of the herbicides atrazine, simazine, linuron, diuron, and terbacil did not occur after repeated applications at fairly high rates on uncultivated orchard soil. However, phytotoxic levels of diuron and terbacil still persisted for 3 yr after the applications were discontinued. Paraquat, sprayed on orchard soil annually for 9 yr, penetrated to a depth of 10–15 cm in spite of the high absorption capacity of the surface layers.

Orchard management systems for peaches. An orchard of Harken on Siberian C rootstocks was planted in 1973 to test the individual and combined effects of three levels of irrigation and three tree spacings on tree growth, yield, and orchard longevity of peaches. In 1974 application of irrigation water, when the available soil moisture at the 20-cm depth dropped to 50 or 25%, increased trunk growth 50% and terminal growth of scaffold limbs 25%. Tree spacings of 3.1×6.1 , 4.6×6.1 , and 6.1×6.1 m did not affect tree growth.

Pruning systems, yields, and harvest efficiency. Data on yield and harvest efficiency were obtained from a pruning demonstration orchard planted in 1969 (Olinda/Rutgers Red Leaf). Four pruning systems were compared, each at a different planting density, but the density chosen in each case was considered optimum for the system. The pruning systems were: modified oblique palmette (MOP) at 558.4 trees/ha, modified canted oblique palmette (MCOP) at 746.2 trees/ha, central leader cylinder (CLC) at 536.2 trees/ha, and standard open center (SOC) at 383 trees/ha. Corresponding yields were 31.49, 23.60, 21.32, and 18.02 t/ha. In southwestern Ontario SOC is the standard system. When yields were compared with that of the control (SOC), the best system was MOP (75.0% higher), followed by MCOP (31.0%) and CLC (18.4%). Harvest efficiency was measured in terms of man-hours required to harvest a metric ton of fruit. The most efficient system compared with the control was MOP, which required 61.3% fewer man-h/t. The next best system was MCOP, which required 49.9% fewer

man-h/t, and the most inefficient system was CLC, which required 16.1% more man-h/t than the control. In the MOP and MCOP systems, 97% of the fruit was removed by use of a mobile platform, but in the CLC and SOC systems, less than 90% could be removed in this way, the remainder being harvested from the ground. The MOP system was best in all aspects of the systems tested.

Rootstock influence on cold hardiness of scion cultivars. Redhaven scions on two peach seedling rootstocks, Siberian C and Harrow Blood, were sampled during the fall, early winter, midwinter, and spring, and parallel freezing and carbohydrate analysis tests were conducted on each sample date. In the case of the rootstock Siberian C, enhancement of scion hardiness was evident as early as October before leaf fall. This was interpreted as a direct influence of rootstock on enhanced photoperiodic response of the scion cultivar (Redhaven) to short days, resulting in earlier cold acclimation. In December and February, significantly higher levels of carbohydrates in the form of starch and sugars were found in Redhaven/Siberian C than in Redhaven/Harrow Blood. Also, scions of Redhaven/Siberian C were significantly more bud-hardy than those of Redhaven/Harrow Blood. It was postulated that another effect of the Siberian C rootstock on scion hardiness may be an influence on the rate of carbohydrate depletion of the scion that results in a higher accumulation of cryoprotective materials and thereby enhances scion hardiness.

The exotherm method for measuring bud hardiness. Exotherm analysis was used to determine the cold hardiness of 10 peach cultivars. The average exotherm temperature was significantly correlated with the temperature at which 50% of the flower buds were killed ($r = +0.880$). Both measurements of hardiness were also correlated with natural bud mortality of the 10 cultivars averaged over 4 yr.

Weed control. A commercially available string impregnated with atrazine, simazine, and diuron at 2.2, 6.6, and 2.2% levels, respectively, gave excellent weed control in nursery rows of peach and apricot. A single strand of string placed on the soil surface (Fox sandy loam) in November 1973 controlled weed vegetation in a band 15.24 to 25.40

cm wide in 1974, eliminating the need for cultivation in the tree row. No injury was observed on the seedling trees in 1974. Chemical analysis of the string indicated that 87% of the chemicals were removed from the string from mid-November to the end of April, the preferred time of year to have it present in the soil.

Pears

Breeding. Breeding work continues on the development of cultivars resistant to fire blight and with fruit of high quality for the processing and fresh markets. To date, three fire-blight-resistant pear selections, HW600, HW601, and HW602, have been released for trials by growers and stations elsewhere.

Fire blight. A control program emphasizing the application of streptomycin foliar sprays after each rainfall during the period from blossoming to 30 days before harvest reduced twig blight by approximately 80% in 1974. Related studies involving disease assessment and epiphytic populations of *Erwinia amylovora* (Burr.) Winsl. et al. indicated that disease broke out after detection of the bacteria on the leaf surfaces. An association between twig blight and the epiphytic bacterial population was established for June, July, and August. Neither disease nor bacteria were detected before June.

Flavor and aroma components. In taste panels conducted on canned pear halves, Bartlett, several sports of Bartlett, and the selection HW602 were found to have a special intense aroma not present in other cultivars in the Harrow pear collection. This intense aroma is one of the main attributes of the high quality for which Bartlett is known. The decadienoate esters, which are the main flavor components of pear fruit, were present at high levels in cultivars that had Bartlett aroma. Measurement of decadienoate ester level may provide a convenient objective test for selecting seedlings with Bartlett aroma in pear progenies.

Rootstocks. Three *Pyrus* dwarfing rootstocks from Oregon and virus-free Quince A were propagated for trials with growers. Sixteen other Oregon *Pyrus* rootstocks, which were not as fully tested, were propagated for trials at the Station before release to growers. Six *Pyrus* rootstocks from South Africa have been also received for Station trials.

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D. R. GIBSON, B.Sc. (Agr.)	Corn
R. W. ROBERTSON, B.S.A.	Plant introduction
H. D. VOLDENG, B.S.A., M.Sc., Ph.D.	Plant physiology
F. S. WARREN, B.S.A., M.Sc., Ph.D.	Corn

Horticultural Crops

G. R. JOHNSTON, ¹ B.S.A., M.S.A.	Potatoes
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Experimental Farm, Kapuskasing, Ont.

J. M. WAUTHY, B.Sc. (Agr.)	Superintendent; Crop management and evaluation
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Experimental Farm, Smithfield, Ont.

H. B. HEENEY, B.Sc. (Agr.), M.Sc.	Superintendent; Plant nutrition and irrigation
H. L. HOUSE, B.S.A., Ph.D.	Insect physiology and nutrition
S. R. MILLER, B.Sc., M.Sc., Ph.D.	Plant physiology and biochemistry
W. P. MOHR, B.S.A., M.S.A., Ph.D.	Food processing
L. G. MONTEITH, B.S.A., M.S.A.	Fruit management, pest control

Experimental Farm, Thunder Bay, Ont.

W. B. TOWILL, B.S.A.	Superintendent; Crop management and evaluation
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Departures

T. BURNETT, B.S.A., Ph.D.	Insect population ecology
Transferred to Ornamentals Research Service, May 1974	
J. E. FISHER, B.S.A., M.Sc., Ph.D.	Cereal crops morphology
Died December 30, 1974	
S. J. LEUTY, B.S.A., M.S., Ph.D.	Fruit crop management
Resigned July 1974	
A. G. PLESSERS, B.Sc. (Agr.), M.Sc., Ph.D.	Hybrid winter wheat
Retired October 1974	

VISITING SCIENTISTS

National Research Council postdoctorate fellows

J. G. BOWMAN, B.Sc., Ph.D., 1974-75	Cytogenetics
I. TARUMOTO, B. Agron., Ph.D., 1974-75	Wheat

¹Stationed at University of Guelph, Guelph, Ont.

INTRODUCTION

The program of the Research Station, Ottawa, emphasizes research on crops for animal feed, including cereals, corn, and forages. A new timothy cultivar was licensed in 1974 and a scab-resistant apple cultivar was named and released; it was developed from a program that is now discontinued.

A promising start has been made on the new program on experimental haploidy, which includes studies on haploid production in several species and cell regeneration from cultures of leaf protoplasts of *Linum* spp.

Dr. A. G. Plessers retired after 20 years at the Station, during which he made valuable contributions to the breeding of flax, field beans, and, in recent years, hybrid wheat.

Dr. J. E. Fisher died suddenly in December 1974. His excellent research on developmental morphology in relation to yield and selection criteria was an extremely valuable part of our cereal crops program.

This report summarizes some of the more important research results from the Station in 1974. Further information can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

F. K. Kristjansson
Director

CEREAL CROPS

Wheat and Triticale

Breeding. The new soft white winter wheat Fredrick, released in 1971, has proved to be the highest yielding winter wheat in Ontario. It is rapidly becoming the most widely grown winter wheat in the province, both commercially and as pedigree seed. Although it will be difficult to produce a cultivar superior to Fredrick, two test entries show promise. One, 8077 B92-1, combines high yield with short straw and another, 0-18-3, high yield with superior winterhardiness. Weather conditions experienced at Ottawa during 1973-74 made it possible to select for winterhardiness.

Winter-type derivatives of triticale that range in appearance from true triticale types to wheatlike plants have been developed by the Station at Ottawa over a period of years. In 1973-74 several thousand strains were evaluated in nurseries at Ottawa, and a few advanced lines were tested for yield at Ottawa, Guelph, Ridgetown, and Harrow. In general, no major advances were made in raising the yields above those of winter wheat. Some strains, however, showed a tolerance or resistance to wheat spindle streak mosaic virus. The plants were somewhat taller than commercial winter wheat cultivars and varied in their resistance to lodging. Seed quality also varied in both the degree of shriveling and the protein content. The Research Station at Ottawa invites

scientists who are interested in evaluating a cross section of the winter triticale material to request seed.

Quality. Chemical analyses of 108 strains of spring, winter, and durum wheats and triticales showed that little variation exists in lipid content, fatty acid composition, fiber content, ash content, gross energy, and in vitro digestibility. In contrast, yield, 1000-kernel weight, and protein content varied considerably. Estimates of heritability were low for protein content and yield but high for 1000-kernel weight. Genotype correlations between percent lysine and protein content were significant and negative, but environmental correlations between these two characters were not significant.

Winter survival. A uniform degree of stimulation in the biosynthesis of linolenic acid, resulting in a net increase in the unsaturation of membrane lipids, occurs at low temperatures in four wheat cultivars of contrasting hardiness. The phenomenon, therefore, is not directly related to resistance to freezing temperatures, at least in the range of -5 to -18°C, but is probably a general response and adaptation to growth conditions at low temperatures.

Virology. Wheat spindle streak mosaic virus was found mainly in the top 20 cm of soil in a wheat field at Ottawa, but traces occurred down to about 50 cm. The virus was

transmitted in water from roots of wheat plants that became infected from the soil. It was not transmitted from plants that were grown in sterile soil but infected with the virus by artificial inoculation of the leaves. When infectious soil was treated with the fungicide Dexon (Bayer AG) at a dosage greater than 90 μ g/g, wheat suffered less or no infection from the soil. However, at lower dosages the amount of infection increased. About 30 triticale lines, some of which are wheatlike in appearance, were resistant to the disease in the field for the 2nd year.

Oats

Breeding. Scott, the new cultivar of oats released by the Station in 1972, continued to be the highest yielding in Ontario. To add to the inventory of cultivars, two new entries, OA123-124 (grain-type) and OA123-81 (forage-type), are now ready for license. Both are of interspecific origin, derived from crosses of *Avena sativa* \times *A. strigosa*². Significant progress was made in combining high seed yield with naked seed (OA287-4, OA288-2, and OA290-5) and with insensitivity to day length (OA266, OA269, OA272, and OA313). Attempts to combine high seed protein with high fat content were at least partly successful (18–20% protein with 7–8% oil in groats), but the selections have not been evaluated for yield potential. The newly discovered dominant dwarf gene (R. I. H. McKenzie, Res. Sta., Winnipeg) was successfully transferred and backcrossed to 49 tall cultivars and strains. A few of these crosses produced plants with short stature and with panicles that have long peduncles.

Physiology. A screening test for seedlings was developed which differentiates between cultivars or selection lines with high and low protein contents in the grain. The test involves a visual rating of the color of senesced sections excised from the first leaf of plants grown in a controlled environment. The leaf sections senesce for 4 days under specified conditions in the presence of a buffered kinetin solution. The high-protein cultivars had significantly higher chlorophyll contents per unit area of leaf section than the low-protein cultivars, both before and after senescence. This difference is more clearly visible in the senesced material, when less chlorophyll is present. Moreover, the low-protein cultivars lost more of their chlorophyll during senescence in the presence of

kinetin than did the ones with high protein. This screening test will be used in the oat breeding program to produce high-protein oats with better yield than the cultivar Hinoat.

Diseases. A major advance has been made in the knowledge of *Septoria* development on oat plants, and the expression of resistance. The disease is normally severe in the Maritime regions of Canada. In a growth chamber, oat plants inoculated with *Septoria* spp. were submitted to high humidity and cool temperatures that approximated Maritime conditions. The fungus became systemic in the host and spread through the leaves, into the stems, and eventually throughout the plant. When the disease developed it reduced plant height and seed yields, but its severity varied among the oat strains. A few cultivars and wild species remained relatively free from disease and showed good resistance as adult plants. The fungus failed to become systemic in these plants.

Barley

Breeding. The new barley cultivar Vanier released by the Station in 1972 proved to be the highest-yielding cultivar in Ontario. A new strain, OB128-10, with greater straw strength than that of Vanier, is ready for license. Doubled haploid plants of barley produced at Ottawa were included in replicated yield trials in 1974. Of the 61 lines tested, 17 equaled or exceeded the best control cultivars in yield, 16 in kernel size, and 5 in grain weight. Fourteen lines matured earlier than the earliest control cultivar. The doubled haploids showed a wider range of values for each of these characters than the controls, which means that selection can be pursued in either direction. The advantage of selection in doubled haploid material over conventional early-generation selection is that the material is homozygous and stable.

Cytogenetics. The problem of attaining fertility in autotetraploid barley appears to be insurmountable. Fertility and meiotic behavior were related in autotetraploids, amphiploids of *Hordeum vulgare* \times *H. murinum*, and hybrids between the two groups. No reduction of quadrivalent frequency or increased fertility was realized in the hybrids. Fertility was related to A-I disjunction rather than to quadrivalent frequency.

Quantitative genetics. In a 6×6 complete diallel cross experiment with short and tall six-row spring barleys as parents, the space-planted F_1 generation showed considerable heterosis (39%) in grain yield. Nonadditive gene effects were largely responsible. Reciprocal effects were also significant for most characters studied. The WR/VR graphs indicated overdominance for yield and dominance of the higher-yielding parents. Heterosis for yield was lower in the space-planted F_2 (33%) and about halved in the solid-seeded F_2 (19%). In growth-chamber experiments with hybrids of winter \times spring barleys, heterosis was found to depend on temperature and day length.

In the space-planted F_2 generation from a 5×5 complete diallel cross of two-row spring barleys, there was slight positive heterosis (13%) in grain yield but negative heterosis (-6%) in percent protein content. A similar relationship was found in growth rooms, where long, cool days resulted in high yields and low protein content and short, warm days, low yields and high protein content.

Winterhardiness. In vitro freezing tests conducted in cooperation with Dr. C. Andrews, Chemistry and Biology Research Institute, revealed that winter barley hardened in the fall to nearly the same degree as winter wheat. However, it lost this hardened condition more quickly over the winter, so that it was more vulnerable to frost injury in the spring. The second finding, not previously reported, is that barley is virtually unable to tolerate an ice cover. Hardened (vernalized) seedlings of barley survived only 2 days when covered with ice (-2°C), whereas wheat tolerated the same treatment for more than 5 days and rye for more than 7 days.

Developmental morphology. The barley strain OB128-1, which originated from an anomalous cross between *Hordeum vulgare* and *H. murinum* (*H. leporinum*), backcrossed to *H. vulgare*, produced rudimentary apical spikelets in 40-50% of the population examined. The spikelets varied in development from a distorted glumelike structure, to a well-initiated apical spikelet containing a floret primordium. None produced a functional floret. Attempts to find an apical spikelet in numerous cultivars of *H. vulgare* have failed, as they have with *H. murinum*. However, interspecific hybrids are often

unstable and develop anomalous organ structures not present in either parent. An apical spikelet in barley is considered to be a detriment to head length and hence yield, because its presence limits spike length as it does in wheat and rye. The new selection OB128-1 has now been reselected for head length and is being tested for the presence of apical spikelets.

CROP LOSS ASSESSMENT

Methodology

Determination of yield loss of field beans due to bacterial blight. A model was developed to assess yield losses from bacterial blight caused by *Xanthomonas phaseoli* (E.F.Sm.) Dows. in field beans. The model uses a yield loss factor of 38, determined from the average yield loss in 2-yr field-plot trials, combined with information on the incidence of bacterial blight in commercial bean fields in Ontario as determined by infrared (IR) photography from aerial surveys conducted in 1968, 1970, and 1972. Losses for the field bean crop in Ontario varied from over 1 251 913 kg (46,000 bu) in 1970 to only 217 724 kg (8,000 bu) in 1972.

Remote sensing. A method was developed to determine the optimum time for aerial IR photography of field beans infected with bacterial blight. Optical density levels were determined from aerial IR films of healthy and diseased bean plots, taken at intervals during the growing season. Optical density levels of healthy and diseased plots showed obvious differences on August 2 (1972) and August 5 (1971), and throughout the growing season. The greatest differences between the optical transmission densities were found in films taken on August 15-20. This peak indicates the optimum photographic potential, that is, the time during the growing season when the canopy and chlorophyll content of the crop are greatest and diseased plants provide maximum contrast to healthy areas in the field.

Foliar diseases of alfalfa. A simplified sampling method was developed to estimate the incidence of common leaf spot, stemphylium leaf spot, and downy mildew in farmers' fields in eastern Ontario. The method involved examining five plants at 10 equally spaced sites along a 90-m pathway

positioned midway between one corner and the center of a field.

In another study, greenhouse experiments showed that the weight of alfalfa leaves was not significantly reduced because of leaf spot diseases and that the percentage of defoliation would provide a direct estimate of yield loss.

Root rot (Fusarium solani and related species) in peas. Field plot experiments with 10 pea cultivars showed that moderately infected plants suffered an average of 22% yield losses (dry seed weight) and severely infected plants, 40%. The individual cultivars did not require use of separate yield loss factors. Pea samples from farmers' fields in five provinces showed that plants severely affected by root rot gave 60% lower yields than those of apparently healthy plants. When data from experiments and from farmers' fields are averaged for the past 3 yr, it is apparent that a loss factor of 0.5 multiplied by the proportion of severely affected plants provides a reasonable estimate of yield loss due to common root rot.

Late blight forecasting. A computer-based forecasting scheme was successfully operated for farmers in the area of Thunder Bay in 1974. After a disastrous epidemic of late blight in 1973, farmers requested help because they lost 50–60% of their potato crop valued at \$150,000. As a result of the forecasting scheme operated in 1974, losses were negligible.

Surveys

New disease problems. Plant pathogens reported for the first time in Canada include a new race of the flax rust fungus, *Melampsora lini* (Ehrenb.) Lév., and *Ascochyta rabiei* (Pass.) Lab., a destructive seed-borne pathogen of *Cicer arietinum* L. (chickpeas).

Ergot. An unusually high incidence of ergot was reported in shipments of durum wheat inspected at terminal elevators during 1973. However, field surveys in 1973 and 1974 showed that levels of ergot have declined in the southern areas of the Prairie Provinces where most of the Canadian durum is produced; in common wheat, low levels of ergot were more prevalent in the northern portion of the wheat-growing area.

Field beans. In 1974, surveys by aerial photography and on the ground were conducted on 115 bean fields in two areas of

southwestern Ontario: 97 fields comprising 1007.7 ha (2,490 ac) in the Hensall area, and 18 fields comprising 100.3 ha (247.8 ac) in the Chatham area. Only four fields were infected in the Hensall area, and those in amounts too small to be scanned. Eleven fields were infected in the Chatham area and the material has been prepared for scanning to determine the area infected. The overall infection level was less than 0.2%.

Missing plants in potato fields. In a cooperative study with the Research Station at Fredericton and the Statistical Research Service, the extent, cause, and distribution of missing plants in the New Brunswick potato crop were evaluated. In 1973, the average crop had 32% missing plants, resulting in a loss of approximately \$4 million. The problem has been referred to agricultural engineers because in most cases the cause of the miss was the absence of a seed piece, indicative of inefficient planting operations.

Barley diseases. Surveys of leaf and root diseases in fields of barley in five counties of western Ontario showed that leaf diseases were much less severe in 1974 than in 1973. However, spot blotch caused by *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. was again the most prevalent disease. Estimates of losses due to root rot were slightly less than 1%.

CYTOGENETICS

Oats

Aneuploidy. In addition to the seven primary trisomics, five telocentrics and two secondary trisomics have been isolated and identified in the diploid species *Avena stri-gosa* Schreb. Four of the telocentrics represented the opposite arms of chromosomes M3 and SM5, respectively. The frequency of trisomics was higher in the small seed fractions among selfed progenies. No straightforward relationship was apparent between chromosome length and formation of trivalents, but trivalent formation and transmission rate of the trisome were related. The highly effective stem rust gene *pg-13* was tentatively located on chromosome ST20 in *A. sativa* L.

Electrophoresis. The esterase pattern of *A. canariensis* Baum. Rajhathy, & Sampson was distinct from that of the C-genome diploids.

and it was more homologous with *A. magna* Murphy & Terrell, *A. murphyi* Ladizinsky, and *A. sterilis* L. than with other A-genome diploids. The combined morphological, karyotypic, and electrophoretic evidence suggested that *A. canariensis* is the putative donor of the A genome to the polyploid cluster cited above.

Bromegrass

Analysis of chromosome pairing in octoploid F_1 hybrids of *Bromus pumpellianus* Scribn. \times *B. inermis* Leyss. is difficult, but pairing appeared to be mainly bivalent as in the parent species. The frequency of lagging univalents at anaphase I and micronuclei in tetrads was similar to those found in the parental species. Hybrids between tetraploid *B. pumpellianus* Scribn. ssp. *dicksonii* Mitchell & Wilton and tetraploid *B. inermis* were more suitable for meiotic analysis. The univalent frequency in the hybrids was higher than in the parent tetraploids. Further analysis is necessary to determine if this is indicative of genome differentiation.

Several introductions of pasture-type *Bromus* spp. may give earlier growth in spring and better pasture production in late summer and fall than *B. inermis*. These or similar *Bromus* spp. may be useful in land areas suitable for permanent pasture.

Experimental Haploidy

Tobacco. Anthers of *Nicotiana tabacum* L. cultivar Delhi 34 were cultured on a variety of defined culture media. The frequency of anthers that yielded haploid embryoids ranged between 5 and 35%. It was concluded that the technique is suitable for use in breeding programs and it was therefore introduced to the program of the Research Station at Delhi.

Rapeseed. Approximately 40 plants were obtained from cultured anthers of *Brassica campestris* L. cultivar Torch. A high sucrose level (10%) and glutamine (0.005 M) were essential for embryoid development. Meiotic studies revealed the presence of a triploid and two tetraploids; the remaining plants were diploid. The striking differences between the plants in both morphology and development strongly suggested that they were derived from pollen. Some plants produced both selfed and crossed seeds.

Flax. Of the 69 haploids obtained from haplo-diplo twins of Rocket-4, a genotype

selected for a high rate of twinning, 58 were doubled and increased. Forty-four cultivars were screened for haplo-diplo twinning and four were found suitable for selection of high-twinning new genotypes. Haploids, increased by cloning, were backcrossed with normal and mutagen-treated pollen for the production of genetic markers and for screening of mutants that tolerate low temperatures. Protoplasts were isolated from leaves of the cultivar Redwood 65 by treatment with enzymes. Subsequent culture in liquid medium resulted in wall regeneration and cell division.

Wheat. Nine haploid plants of *Triticum aestivum* L. cultivar Pitic 62 were obtained from anthers cultured on Miller's medium at a high sucrose (6%) level. All the haploids reached the adult stage and some seeds were formed in colchicine-doubled sectors. Seeds were also obtained from pollinations of haploid florets with normal Pitic 62 pollen. Clones of each of the haploids are being maintained.

ENTOMOLOGY

Insect Population Dynamics

Alfalfa weevil. Populations of the alfalfa weevil, *Hypera postica* (Gyll.), again attained epidemic levels in 1974 and in many parts of southern Ontario damage to forage crops was at an all-time high. Numbers of eggs in study plots within the population epicenter of Hastings-Northumberland reached a record 9900/m² (921/ft²). Cohort life tables showed that within-generation survival decreased 20-fold. This was the second consecutive decrease and foreshadows a local population decline with eastward shift of the focus of infestation. The disruption was caused by an epizootic of the fungus *Entomophthora phytonomi* Arthur, a pathogen not previously recognized on the alfalfa weevil. In some fields the epizootic destroyed more than 99% of the feeding larvae. The fungus has been isolated and cultured on egg-yolk medium.

A statistically reliable sampling plan has been developed for estimating numbers of larvae in green stems of alfalfa. A six-stem bouquet of foliage is used as the sample unit. The bouquets are collected from within random quadrats of alfalfa and brought to the laboratory where they are placed in small

Berlese-Tullgren funnels. The activated larvae fall into containers of alcohol. For typical densities of the weevil, population estimates with acceptable probability and precision may be obtained by taking a single bouquet from as few as 16 random quadrats within a field, at a total cost of 2 man-hours.

A sequential system has been devised for rating the economic potential of weevil infestations. Designed to provide more lead time in making management decisions, it entails counting the oviposition punctures in a sequence of three-stem bouquet samples of alfalfa. An appraisal of the plan under field conditions showed that it rated the infestation correctly in 39 out of 40 cases. Time to reach a decision averaged 35 min.

Honey Bees

Behavior. Synthetic 9-oxo-*trans*-decanoic acid was found to attract as many male bees (drones) as did extracts of queens, indicating that this compound is the component of the queen pheromone that attracts drones from a distance. However, the synthetic product did not cause the drones to hover, indicating that still other components are involved in the mate-finding process. More acid is produced by laying queens than by virgin queens, and "keeper" substances secreted together with the pheromone ensure its gradual release and dispersal.

Diseases. Infectivity of spores of *Bacillus larvae* White, the causal organism of American foulbrood, was reduced when pollen was incorporated into the larval food. Saturated fatty acids contained in the pollen were found to suppress growth and inhibit sporulation of the pathogen in vitro, and also in larvae reared in the laboratory or beehive. The fatty acids were not as inhibitory as oxytetracycline (Terramycin) fed in syrup, but synthetic acids of the short-chain type showed promise as a prophylactic.

FORAGE CROPS

Grasses

Orchardgrass. In 1974, 1400 kg of Foundation seed of Juno orchardgrass were harvested, so that plantings of this early pasture-type variety can be increased for the production of pedigreed seed. Progeny of the Juno genotype continued to be tested for seed yield and rust resistance. Mean seed

yields from progeny lines varied from 8 to 75 g per plant. Individual plants that scored 0 and 1 for rust resistance were noted in September 1974. Further selection for seed yield and rust resistance in the Bumper strain, and in Kay and Rideau genotypes, has given positive results.

Timothy. A new variety, Basho, was licensed in February. It is a pasture type similar to Champ but taller, slightly higher-yielding, and with a higher potential for seed yield. Significant progress has been made in selection for tallness among individual plant progenies of the Labelle strain genotype. The 50 plants selected varied from 40 to 55 cm in height, whereas mean height of the Labelle strain was 35 cm. Continued cycles of selection for seed yield per plant have been recorded for populations of the Labelle strain, the S3-2 strain, and Basho. In open-pollinated lines of Basho, mean seed yield varied from 12 to 42 g/plant. Because timothy is in intense competition with other cash crops in the prairies, selection for higher seed yield is being given high priority.

Dry matter from 33 pasture-type clones of timothy grown in the greenhouse and cut four times at monthly intervals was determined in vitro. It varied from 63 to 71%, which indicates that digestibility is a valid selection criterion for use in variety improvement.

Bromegrass. The high-seed-yielding synthetic, D-9, was recommended for licensing by the Ontario Forage Crop Committee in November 1974. Although the forage yield was similar to that of the recommended variety Saratoga, the increased seed potential of this variety was the main reason for the recommendation. Also, a reduction in yields of the cultivar Baylor indicates that a replacement may be needed. A description of D-9 was completed under the name Tempo.

Alfalfa

Angus and Algonquin alfalfas have become firmly established as two useful cultivars. In 33 station-years of forage trials, Angus was at least equal to Saranac, and Algonquin outyielded Vernal by 5%. Seed multiplication is progressing satisfactorily. Over 8450 kg of Foundation seed of Algonquin and 4360 kg of Angus were produced in 1974, so that sufficient Certified seed can be produced in 1976 to satisfy foreseeable

markets. Some Certified seed of both cultivars was produced in 1974 and therefore they were placed on the Ontario recommended list.

Breeding methods. Breeder seed of BW9 is being increased in expectation of licensing. Another evaluation of the allelic method of selection was made when a field trial was established for 143 F_1 progenies and their parental synthetics BW1 and BW9.

Corn

Breeding. Delayed planting, drought, and below-normal temperatures in mid-season, followed by early frost, seriously affected growth and development of corn in nursery and test plots. Material that normally requires the full season to mature did not ripen, so that reliable evaluations could not be made. Conversely, material that reached maturity after being subjected to the unusual stresses of the season showed exceptionally high levels of stalk rot. One benefit of the adverse season was that it provided a stringent test for stalk quality in the earlier material.

Performance of Ottawa experimental hybrids in Ontario Corn Committee tests was also affected. Four out of six tests containing these hybrids had to be discarded. On the basis of the limited data available, two entries, OX519 and OX521, appeared to be competitive and will be tested again in 1975.

Off-station testing of Ottawa experimental hybrids for grain was expanded in 1974 to include four sites in the Atlantic provinces. In yield trials at three of four locations, four hybrids were identified that successfully reached physiological maturity. These were significantly earlier than the control hybrid Haapala 175, currently the earliest licensed hybrid available, and gave comparable yields.

Growth and development. The response of corn to stress imposed by interplant competition was studied in an experiment where row width, distance between plants within the row, and number of plants per hill were varied. As in 1973, plant arrangement had only a small effect on the yield of grain; the area of land per plant was the critical factor.

Agronomic practices. Harvest losses were studied in grain corn planted at densities ranging from 35 000 to 86 000 plants/ha and at four planting dates from mid-May to

mid-June. All plots were harvested by a modified picker-sheller on the same date. Grain losses ranged from less than 2% to more than 10% of the yield. In general, losses were greater at the higher plant densities but some low-density plantings had high losses. The later plantings also suffered greater losses. Some of the variability was probably due to unfavorable weather conditions, and further testing is required.

In herbicide studies, butylate, alachlor, cyanazine, and 2,4-D amine were used alone and in combination with atrazine applied premixed and separately to control annual grasses and broad-leaved weeds in corn. Every treatment gave some degree of weed control and increased corn yield. Use of atrazine improved the efficacy of each of the other herbicides. With butylate and alachlor, much better results were obtained when they were premixed with atrazine than when applied separately. For the other two herbicides, better results were obtained with separate applications. The various combinations of materials, applied either premixed or separately, caused variable rates of injury to corn plants, depending on the herbicides used.

Soybeans

Breeding. Two Ottawa lines entered in the Ontario 2500–2700 Heat Unit Area Test placed first and fourth of 12 entries in seed yield. These lines outyielded currently recommended varieties and generally matured about 5 days earlier. Strains with high protein content do not yet yield as much seed as the best high-oil lines, although one high-protein line produced 94% as much as the standard cultivar, Altona.

Biochemistry and physiology. Correlation analyses among oil, protein, fatty acids, and seed yield of 30 strains in the breeding program demonstrated a positive correlation between oil and yield and negative correlations between oil and polyunsaturated fatty acids, and between protein and yield. Therefore, selection for high levels of oil can be expected to improve seed quality by decreasing polyunsaturation and increasing the total metabolizable energy. Success in combining high levels of protein with high seed yields is not favored by the negative protein–yield correlation in the Ottawa strains. The absence of such a correlation among the F_6 progeny lines of the cross Blackhawk \times

Glycine ussuriensis obtained from the breeding program at Harrow indicates that hybridization among genetically diverse sources of germplasm may be necessary.

A modified sample holder developed by the Cereal Quality Laboratory requires only 3 g of ground seed for infrared spectroscopic analysis in the Neotec grain quality analyzer, so that adequate residual seed from a single plant remains for planting the following season.

Pathology

Chemotaxis of Phytophthora megasperma. *P. megasperma* Drechsl. was found to be the most destructive fungus associated with alfalfa root rot in North America. The attraction of zoospores toward the roots of the alfalfa plant is important in the development of this disease. A phenomenon concerning the chemotaxis of the zoospores to alfalfa roots was observed. The roots of a susceptible alfalfa variety attracted sporangia and zoospores of *P. megasperma* to an obvious degree within a short time. With few exceptions, chemotaxis first appeared in the region of elongation immediately behind the oldest portion of the root cap, and it eventually became prevalent farther back in the region of differentiation. However, there was no indication of attraction of sporangia or zoospores in the region of the root cap and in the mature zone. The phenomenon of zoospore attraction in susceptible alfalfa varieties tends to be rather specific; the roots of a resistant variety, Agate, did not attract the zoospores in any regions of the root. The glass rods used as controls neither attracted nor repelled the zoospores.

Introductions

Several introductions showed promise in small plot trials in 1974: two alfalfas, *Medicago falcata* L., one from USSR and one from Germany, and two alfalfas, *M. sativa* L., from France outyielded the controls, Iroquois and Saranac, in forage production; flat peas, *Lathyrus silvestris* L., from USSR gave double the forage yield of our best alfalfas on a one-cut basis; bromegrasses, *Bromus inermis* Leyss., from Belgium and Norway gave higher forage yields than Redpatch; orchardgrasses, *Dactylis glomerata* L., from Germany and Finland were hardy and higher in forage production than Rideau; timothy, *Phleum pratense* L., from

France outyielded all other forage grasses in one cut; Kentucky bluegrass, *Poa pratensis* L., from USSR, a very tall, vigorous strain with high forage production, showed promise as a pasture species and has tolerance for mildew.

From a survey of old meadows in eastern Ontario, 250 alfalfa ecotypes that had persisted for 10–20 yr were gathered.

An increase block of a new cicer milkvetch, *Astragalus cicer* L., yielded 580 kg/ha of Breeder seed. An increase of a new Ottawa tetraploid red clover produced 130 kg/ha of Breeder seed.

HORTICULTURAL CROPS

Potatoes

Breeding and testing. Onaway, an early-sizing, drought-resistant, tough-skinned, scab-resistant cultivar, bred in Michigan, was licensed in 1974. Also licensed in 1974 was Belleisle (formerly Fredericton seedling F58010), a maincrop potato variety with good yielding ability, and excellent quality for boiling, baking, and french fries. It is resistant to late blight and storage rot, and very resistant to tuber damage due to handling. Fredericton-bred F61025 will be recommended for release in 1975. It is medium-early in maturity, a good yielder, resistant to leaf roll virus and verticillium wilt, excellent as table stock, and good for chipping.

PLANT GENE RESOURCES

Collections maintained in Canada. A first listing of the collections of plant genetic resources maintained by 167 plant breeders and other plant scientists was published in 1974. The report lists plant genera (and species) represented in the collections together with the number of stocks maintained in each collection. Eighty-one genera (from *Acer* to *Zizania*) are represented in the collections, which contain over 86,000 stocks.

Seed storage facilities with temperature and humidity control. Seed stocks from the "Base Collection of Canadian Plant Gene Resources" and the "Canadian Wild Oat Gene Pool" (CAV Collection) are stored under controlled temperature and humidity in a new seed storage room acquired in 1974. The facilities will be used also to maintain in working collections small seed samples of

genetic resources from discontinued breeding and research programs.

EXPERIMENTAL FARM, KAPUSKASING, ONT.

Forage Management

Longevity of alfalfa compared with brome-grass and timothy. The performance of alfalfa sown five times was compared with that of brome-grass and timothy sown only once, over 10 yr (1962–73) under a two-cut system. Adequate levels of P and K were supplied to all species. Brome-grass and timothy also received additional levels of N starting in 1967. Alfalfa produced good dry matter yields in the 1st and 2nd yr after establishment. In the 3rd yr, the average yields were only about 35% of those in the first 2 yr. In comparison with the control, the average dry matter yields of grasses in 1967–73 almost doubled with an application of N at 67 kg/ha (59.7 lb/ac) and tripled with 201 kg/ha (199.3 lb/ac). Timothy appeared to produce a much lower aftermath when the supply of N was limited. After the first fertilization with N (1967), the dry matter yields of the grasses increased for 3 yr, dropped slightly in 1970, then stabilized in the following years with adequate N. Application of N had a positive effect on the percent crude protein, especially on the first cut. On a 6-yr average, the amount of crude protein produced (measured in kg/ha) increased linearly with N application up to 201 kg/ha (199.3 lb/ac). Brome-grass increased protein production faster as N levels were increased. Under proper management, grasses can be produced more cheaply in the Northern Clay Belt than alfalfa in respect to dry matter yields, and brome-grass can produce as much protein per hectare as alfalfa.

Comparison of various species for early and late pasture. In a 2-yr study of various species managed as early pasture followed by a hay crop and late pasture, Frontier reed canary-grass yielded more than double the other species as early pasture. As late pasture, orchardgrass and tall fescue yielded best. As a hay crop, birdsfoot trefoil appeared to produce well. For the total of three cuts, Frontier reed canary-grass produced the most dry matter.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Fruits

Effects of growth regulators on yields of hedged apple trees. When growth regulators were applied in 1973 to mature Kinkaid Red Spy apple trees hedged in 1970, fruit yield improved substantially. In 1974, a year of heavy yields for Spy, 'slabbed' trees gave an average 54% on the yields of 'unslabbed' controls. Trees treated with daminozide (1500 ppm) in mid-June produced 63% as much fruit as the control trees, but those treated with daminozide (750 ppm) plus ethephon (250 ppm) produced 93% of the yields of unslabbed trees.

Effect of growth regulators on flower bud formation and fruit set. Applications of daminozide, ethephon, or TIBA (Chemagro Corp.) alone, or daminozide in combination with ethephon or TIBA, to 2-yr-old Northern Spy apple trees on M 26 rootstocks in June 1973 increased the number of flower clusters in 1974. The greatest increase in flowers occurred on terminals over 15 cm in length. Only the combinations that included daminozide increased fruit set; the increase was most pronounced on the longer terminals, and was expressed as a doubling in the number of fruit per cluster.

High-density apple orchards. In high-density orchards (2152 to 3588 trees/ha), McIntosh apples planted in three-row beds (3230 trees/ha) produced the highest yields (17.9 + t/ha) on both M 26 and M 9 rootstocks. Trees in the center rows of five-row beds (3588 trees/ha) were significantly less productive on M 26 rootstocks, but not on the less vigorous M 9.

Northern Spy yields were highest in the five-row beds and lowest in single-row plots (2152 trees/ha). An application of daminozide in 1973 brought the trees into bearing in 1974. The quantity of fruit per unit of trunk was higher where trees were sheltered within the beds, even though trunk circumference was reduced in the center rows. Northern Spy on M 9 produced average yields of 14.805 t/ha over all plots whereas on M 26 their average yield was 9.870 t/ha.

Evaluation of Ottawa clonal rootstocks. Evaluations of Ottawa clonal rootstocks at Smithfield and Ottawa indicate that only Ottawa 3 gives rise to dwarfing. With Quinte

as the scion variety, average tree trunk circumference and yield were 26.9 cm and 45.4 kg on M 26 and 27.9 cm and 46.3 kg on O-3. Similar results were obtained with McIntosh as the scion variety.

Rootstocks O-8 and O-12 were similar in size and performance to MM 106 in both trials; O-2, O-5, and O-7 produced slightly larger trees than MM 106; and O-1, O-4, and O-14 resulted in trees equivalent to or larger than those on Robusta 5. Because of poor performance or incompatibility with at least one of the scion varieties, the rootstocks O-5, O-6, O-9, O-10, and O-13 should be discarded.

Scab-resistant apples. Macfree (O-532) was released during 1974. The fruit of this apple is medium to large, round to slightly conic, with 75% dark lively red overcolor. It is of good quality with a storage life of 3-4 mo.

A second very promising seedling is O-652 (O-522 × T-3916); its fruit has an attractive golden skin color with a 5-10% maximum overcolor of light red. This apple appears to be free from the skin blemishes associated with Golden Delicious, has excellent size and a sweet flavor very similar to that of Golden Delicious, and stores until at least February.

Manipulation of orchards to facilitate control of orchard pests. Manipulation of the environment within acceptable horticultural practices favors certain biotic agents. Modifications of the flora on the orchard surface, both as to height and species represented, favored the increase of predaceous mites and entomophagous insect predators and eliminated the need for chemical control of mites, aphids, or scale for 3 yr. On the other hand, parasites (*Opius* spp.) of the apple maggot, which were found at three sites around the Bay of Quinte as well as in the Niagara Peninsula, survive in wild or abandoned stands of apples with shrubby undergrowth. Such an environment would not be compatible with commercial apple production.

Vegetables

Retention of wholeness in canned tomatoes. Retention of wholeness after canning, as measured by ratios of drained solids to fresh tomatoes, is particularly good with some of the new high-color cultivars such as Veebrite, Moira, and Trimson. Even fully ripe fruit severely shaken after canning retain their cohesion.

Such fully ripe fruit subjected to considerable shaking in the can were graded Canada Choice (60% drained solids), whereas older cultivars did not meet the drained solids requirement of Standard grade. The characteristically generous amount and distribution of pericarp tissue relative to locule tissue in the new cultivars suggests that cell wall components such as pectic materials, calcium, cellulose, and callose are involved.

Growth regulators on pickling cucumbers. In field trials for 3 yr, cucumbers were planted at 191 502 plants/ha during the 1st wk of June and harvested once destructively; ethephon (250 ppm) was applied at the three-true-leaf stage, and morphactin (100 ppm) on July 25. As a result, returns on August 5 were 24.2 and 41.8% higher than those of the untreated controls. When the two treatments were combined, returns were higher. The average return of the best treatment over the 3-yr period was \$2700/ha. Later treatments with ethephon or morphactin, or earlier or later harvests, eliminated all benefits.

EXPERIMENTAL FARM, THUNDER BAY, ONT.

Crop Management

Effect of nitrogen and rates of seeding on varietal yields of barley. Nitrogen fertilizer was applied to barley plots at 56.0 and 89.7 kg/ha (50 and 80 lb/ac) in combination with P and K at rates of 134.5 kg/ha (120 lb/ac) and 67.2 kg/ha (60 lb/ac), and the effects were compared with results without added N. Grain yields of Fergus, Paragon, and Conquest barleys were significantly higher with N, most efficient gains occurring at the 56.0 kg/ha rate of N application. In 1972 and 1974, average grain yields were higher by 295.9 kg/ha (264.0 lb/ac) where N was applied at 56.0 kg/ha (50.0 lb/ac), and higher by 368.7 kg/ha (329 lb/ac) with N at 89.7 kg/ha (80 lb/ac). On sandy loam soils subject to drought, higher rates of seeding significantly improved grain production. Barley sown at a rate of 161.4 kg/ha (144 lb/ac) gave average yields for all varieties over 2 yr that were higher by 663.5 kg/ha (592.0 lb/ac) than those from plants sown at a lower rate, 53.8 kg/ha (48 lb/ac). Varieties differed significantly in yield potential, Herta and Conquest being superior to Paragon.

Control of grasses during alfalfa establishment. Dalapon (granular) applied at rates of 2.24, 4.48, and 6.72 kg/ha (2, 4, and 6 lb/ac) as a postemergence treatment failed to provide satisfactory control of reed canarygrass in the early jointing stage of development. Dalapon (wettable powder) applied at rates of 4.48, 9.69, and 13.45 kg/ha (4, 6, and 8 lb/ac) gave excellent control of the grass, with reductions of 90% in stands treated with the high rate of herbicide. Paraquat sprayed at 1.12 kg/ha (1.0 lb/ac) in early September killed all top growth, but before freeze-up the alfalfa showed excellent regrowth.

Control of broad-leaved weeds in alfalfa. Fluchloralin (Basalin; BASF Corp.) was applied at rates of 1.40 kg/ha (1.25 lb/ac) and 1.68 kg/ha (1.50 lb/ac) as a preplanting

incorporated treatment at seeding on June 19. It failed to control the germination and seedling development of redroot pigweed, sow-thistle, and shepherd's-purse in pure stands of alfalfa on sandy loam soil. 2,4-DB at 1.12 kg/ha (1.0 lb/ac), applied postemergence on August 9 to plots previously treated with fluchloralin at 1.12 kg/ha (1.0 lb/ac), gave good control of redroot pigweed, but the treatment was not sufficient to control shepherd's-purse or sow-thistle. Applications of bentazon (Basagran; BASF Corp.) at 1.68 kg/ha (1.50 lb/ac) in early September failed to control dandelion, plantain, chickweed, and shepherd's-purse in a 2-yr-old alfalfa stand. Fall applications of 2,4-DB at rates of 1.05 kg/ha (15 oz/ac) or 1.40 kg/ha (1.25 lb/ac) gave excellent control of young dandelion seedlings, but was ineffective against the more mature weeds present in the alfalfa.

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Research Station

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Fruit pest management

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INTRODUCTION

The programs at this station center around the protection of fruit and vegetable crops against diseases, insects, and nematodes. It was shown that the new disease of grapes, apparently specific to the cultivar de Chaunac (Seibel 9549), is caused by tomato ringspot virus. The disease is soil borne but is readily distributed through cuttings. In cooperation with extension specialists from the Ontario Ministry of Agriculture and Food, insect pests in nine commercial apple orchards in the Georgian Bay area were effectively controlled with less than half the recommended number of applications of insecticide. It has been shown that a foliar application of oxamyl, a nonfumigant nematocide, effectively controls nematodes. The chemical appears to act as a repellent or a feeding deterrent. Certain parameters for effective application of spray materials to fruit trees have been established by using the newly developed experimental sprayer.

Dr. J. H. H. Phillips retired from this station after 35 years of service to the horticultural industry. A pest-management system for peaches has emerged from his most recent studies; it provides satisfactory insect control with about half the amount of insecticide that is usually recommended.

This report briefly outlines some of the highlights of our research in 1974. For more information on our research projects or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Box 185, Vineland Station, Ont. L0R 2E0.

A. J. McGinnis
Director

PESTICIDES

Application

Drift control. Droplet extractors were made and installed on the experimental orchard sprayer. Performance data showed a 40.5% reduction in the number of droplets emitted that were smaller than $80\ \mu\text{m}$ in diam, when the 8002 nozzles were operating at 551.2 kPa (80 psi) and the sprayer air volume rate of flow was $2.8\ \text{m}^3/\text{s}$ (6000 cfm). At 551.2 kPa (80 psi) and $7\ \text{m}^3/\text{s}$ (15,000 cfm) a 36.8% reduction was obtained.

Comparative tests of performance between the experimental machine with droplet extractors and a conventional air-blast machine applying material at the same rate indicate no differences in coverage ($P > 0.05$) in the top inside, middle inside, and middle outside of the trees. Drift losses from application by the conventional machine 70 m (230 ft) downwind were the same as those from the experimental machine at 40 m (130 ft). At 70 m (230 ft) the drift deposit from the experimental machine was negligible. Wind speeds during the tests were 16 km/h (10 mph) for the experimental machine and 10 km/h (6 mph) for the conventional machine.

Comparison of nozzle arrangements on a hydraulic boom in cole crops. In replicated experimental plots of cole crops, coverage was generally lower and damage by cabbage loopers increased when the sprayer traveled 4.3 km/h (3 mph) rather than 3.2 km/h (2 mph). Coverage improved as pressure was increased from 689 kPa (100 psi) to 2067 kPa (300 psi). Drop arms greatly improved control of the looper when flat fan nozzle 8002 was used. Nozzle systems at 689 kPa (100 psi) decreased in coverage and pest control in the order: D₂-33 with drop arms, D₃-25 with drop arms, 8002 with drop arms, and 8002 without drop arms. The 8002 nozzle at 413.4 kPa (60 psi) gave poorer results than at 689 kPa (100 psi).

Chemistry

Stability of benomyl in organic solvents and water. Benomyl was found to be unstable in organic solvents and degraded to methyl benzimidazole carbamate (MBC). Although benomyl also decomposes to MBC in water, the rate of decomposition is not as rapid as had been believed. The misconception that benomyl rapidly decomposes to MBC in water may have developed because benomyl rapidly degrades to MBC in common organic solvents during analytical procedures for

residues, such as extraction, purification, and determination. Benomyl is also thermally unstable, because it breaks down during mass spectrometric analysis at 80°C and also during the codistillation procedure at 100°C.

INSECTS AND MITES

Ecology and Pest Management

Pest management in apple orchards. In 1974, five sprays of insecticide were needed in the experimental and most of the commercial orchards to control apple pests. A prebloom spray to control spring-feeding caterpillars was not needed, but late in August, because the codling moth and apple maggot were still active, an application of an insecticide was needed. In general, the total insect damage in these orchards was less than 2%, and the populations of European red mite were so low that in many orchards an acaricide was not applied. In one experimental orchard where the summer generation of codling moth occurred in very low numbers and the apple maggot was absent, three sprays of phosmet at 3.14 kg/ha (2.8 lb/ac) controlled all pests.

Comparison of prebaited traps for apple maggot. Yellow Sectar pull-down traps prebaited with a mixture of HyCase protein hydrolysate, ammonium acetate, and adhesive trapped significantly more adults of the apple maggot than did Sectar 1 yellow traps prebaited with the same mixture or Pherocon ICPY baited with a solution of soy hydrolysate and ammonium acetate. The largest number of flies was caught with Sectar pull-down traps and the first capture was significantly earlier than with the other traps. Nontarget insects, of which about 95% were Diptera, accounted for approximately 70%, 25%, and 5% of all captures on Sectar pull-down, Pherocon, and Sectar 1 traps. The use of prebaited yellow pull-down traps (obtained from Zoecon Corporation) to determine when to apply the first and subsequent sprays resulted in fewer sprays than are currently recommended for orchards with low or moderate populations of apple maggots.

Long-term effect of acaricides. A 5-yr study in which acaricides were applied once a season to the same apple trees (cv. Delicious) showed that propargite and Plictran (Dow

Chemical Co.) are most suitable for controlling the European red mite, *Panonychus ulmi* (Koch), in a pest-management program. Phytoseiid mites, mainly *Amblyseius fallacis* (Garman), became well established by the fourth year in plots treated with the same compounds and these mites contributed substantially in controlling *P. ulmi*. *A. fallacis* did not develop in plots treated with either chlorphenamidine or formetanate hydrochloride. However, the predator *Zetzellia mali* (Ewing) was relatively tolerant of both chemicals and it may have contributed to control of the red mite. These predaceous mites destroyed a large number of the winter eggs of *P. ulmi*.

Effects of temperature and day length on the carrot weevil. The ranges of threshold temperature for development and reproduction of the carrot weevil in the laboratory were determined in cabinets with 16-h light periods. The range for egg laying is 15–17.5°C, egg hatch and larval development, 12.5–15°C, and pupation, 10–12.5°C. At 20°C laboratory-reared adults did not lay eggs when day lengths were 14 h or less, but adults from the field that had overwintered in an insectary laid eggs when day lengths were as short as 12 h.

Chemical Control

Control of European red mite with benomyl fungicide. Two applications of benomyl on July 30 and Aug. 12 at either 30 g/hl (0.25 lb/100 gal) or 60 g/hl (0.5 lb/100 gal) were equally effective in controlling the European red mite on Redhaven peach. Oil alone at 0.62 litre/hl (80 oz/100 gal) was slightly more effective than benomyl, and benomyl plus oil was significantly better. By Aug. 20 there were about 150 mites per leaf on control trees, whereas there were fewer than 6 mites per leaf on all treated trees. Laboratory studies showed that mites treated with benomyl lay fewer eggs than do untreated mites, and that many of the eggs are nonviable.

Control of carrot insects. Six weekly sprays of chlorpyrifos, tetrachlorvinphos, phosmet, or carbofuran, all at 1.1 kg ai/ha, killed more than 90% of the carrot weevils. Five weekly sprays of carbofuran at 1.1 kg ai/ha killed 95% of the second-generation carrot rust flies in 0.001-ha plots. However, parathion and diazinon at the rates currently

recommended gave only 41% and 34% control.

Evaluation. Of the pesticides currently recommended for use in peach orchards, only azinphos-methyl and parathion were found to give complete control of larvae of the obliquebanded leafroller, *Choristoneura rosaceana* (Harris), in a laboratory test. Maximum kill after 3 days contact with phosmet, phosalone, and carbaryl was 50%, 60%, and 60%.

NEMATODES

Ecology

Population densities and crop loss. Penn-lake lettuce and Chieftain potatoes were grown to market size in clay-tile microplots filled with Bradford muck soil infested with northern root-knot nematode, *Meloidogyne hapla* Chitwood. Losses in weight of marketable head lettuce were 32%, 46%, 54%, and 55% with initial populations of 300, 2600, 15,000, and 27,000 larvae/litre of soil. Losses in weight of marketable potato tubers with 200, 4000, and 11,000 larvae/litre were 28%, 20%, and 14%. At 28,000 larvae/litre, the weight of market-sized tubers increased to 6% more than the controls, and the number of market-sized tubers increased 25%. These increases are attributed to increased stolon production by the heavily attacked plants.

Seedling emergence, production of dry matter, and weight and length of individual shoots of four legumes were reduced in direct proportion to the population density of the northern root-knot nematode, *M. hapla*. Red clover was the most severely affected legume and alfalfa the least. Dry matter produced by each legume with populations of 0, 600, and 20,000 second-stage larvae/kg soil was 11.3, 8.6, and 9.1 t/ha (5.1, 3.9, and 4.1 tons/ac) for alfalfa cv. Saranac; 10.8, 8.2, and 6.4 t/ha (4.9, 3.7, and 2.9 tons/ac) for birdsfoot trefoil cv. Empire; 9.3, 4.0, and 4.2 t/ha (4.2, 1.8, and 1.9 tons/ac) for red clover cv. Ottawa; and 4.4, 4.0, and 2.7 t/ha (2.0, 1.8, and 1.2 tons/ac) for white clover cv. Merit.

Mode of action of nematocides. The nonfumigant nematocide oxamyl applied either directly to the soil in the transplant water or as a foliar spray to cabbage provides the same control of the root-lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev &

Stekh. 1941, as the fumigant-type nematocides. Fumigants produce a rapid initial reduction of numbers of nematodes in the soil, whereas the reduction is gradual over a longer period with oxamyl. Control of nematodes is better with oxamyl than with fumigants, based on numbers of nematodes in the roots 2 wk after transplanting. Results of work in a greenhouse, however, indicate that oxamyl acts more as a protectant from nematode attack than as a nematocide. When oxamyl was applied as a foliar application, reduction in numbers of nematodes appeared to be due largely to starvation.

Physiology

Mitochondria. A technique has been developed for isolating active mitochondria from the fungal-feeding nematode *Aphelenchus avenae* Bastian. Electron microscopic examinations indicate that mitochondria from *A. avenae*, although smaller, are morphologically similar to those isolated from beef heart. Preliminary results show that except for aldicarb and ethoprop nonfumigant nematocides have no noticeable effect on the activity of beef heart mitochondria.

PLANT DISEASES

Fruit Virology

Virus diseases of grapes. The three strains of grape fanleaf virus (fanleaf, yellow mosaic, and veinbanding) have similar virus components. Each strain has an RNA-free protein shell and two types of complete virus particles, middle (M) and bottom (B); $s_{20,w}$ values for the three components are 50, 87, and 122. Infectivity was only associated with the B component, which contains 42% RNA. Polyacrylamide gel electrophoresis showed that the B component from all strains contains two different RNA's and that only the slower moving RNA was infectious. Equilibrium density gradients of the B component yielded two distinct peaks and the infectious RNA was associated with the lighter of the two virus particles. This work was conducted at the John Innes Institute, Norwich, England, by Dr. H. F. Dias while he was on a postdoctorate transfer of work.

The virus isolated from vines of the cultivar de Chaunac (Seibel 9549) showing yellowing and curled leaves, short internodes, poor fruit set, and stunting was identified as tomato ringspot by means of biological and

serological tests. The weeds growing near infected vines were indexed and tobacco ringspot was isolated from common milkweed plants, *Asclepias syriaca* L., with streaking and mosaic symptoms.

Chemotherapy for X-disease of peach. Terramycin was effectively used to induce remission of X-disease symptoms in peach under both glasshouse and field conditions. After one application of Terramycin at dosages below the phytotoxic level, symptom remission was apparently complete for at least 9 mo in the glasshouse and for the growing season in the field. The antibiotic was administered by gravity feed through tubing inserted into small holes bored into the lower trunk; field applications were made immediately after harvest. The solubility and stability of the antibiotic were increased by using citric acid. The treatment, as used, is effective, inexpensive, simple, and commercially feasible.

Superior fruit stock program. The repository for virus-tested material now contains 163 lines of stone fruit including apricot, peach, nectarine, plum, cherry, and ornamental *Prunus*; 123 lines of pome fruit including apple, pear, quince, and ornamental *Malus*; 83 lines of strawberries; and 35 lines of raspberries. All lines are being indexed and trials to verify trueness-to-name are progressing.

Fruit Mycology

Control of leaf curl and canker of peach. A post-leaf-fall application of captafol was more effective than one of ferbam for preventing the shoot-infection phase of canker of peach (*Leucostoma* spp.). Used at this time, captafol was also superior to chlorothalonil and sometimes even to ferbam for controlling leaf curl. Pre-leaf-fall applications of captafol and ferbam were as effective as post-leaf-fall sprays for controlling leaf curl, but early use of captafol was less effective for controlling peach canker.

Vegetable Virology

Viruses of umbelliferous crops. Celery mosaic virus significantly reduced yields of five out of nine commercial celery cultivars grown in Ontario. The other four cultivars appear to possess some tolerance for the Ontario isolate of the virus. At the start, all the cultivars showed small yellow-veined leaves with shortened leaf blades and the plants were noticeably stunted, but as day length and air temperature increased the cultivars Summer Pascal, Slowbolt, Salt Lake, and Non-Bolting Green made considerable recovery. Utah 52-70, Utah 15, Greenlight, Stoke's Golden Plume, and Cornell 619 remained stunted.

Effect of colored polyethylene mulches on the incidence of aphid-transmitted virus diseases in peppers. The incidence of virus and the populations of a common aphid vector of pepper viruses were reduced by the use of colored polyethylene mulches placed between the rows in pepper plots. Aluminum-colored mulch reduced the incidence of virus by 59% relative to the controls. The incidence of virus was reduced by 46% with yellow polyethylene, 39% with red, 31% with green, and 19% with blue. The mean number of aphids per leaf was highest on plants mulched with blue polyethylene and least on those mulched with aluminum polyethylene.

Vegetable Mycology

Effect of benomyl on crucifer pests. Benomyl acted selectively on crucifer pests. At 154 ppm ai based on oventdry soil, benomyl controlled black leg (*Phoma lingam* (Tode ex Fr.) Desm.), yellows (*Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyder & Hans.), green peach aphid, cabbage maggot, and the mite *Tetranychus bimaculatus* Harvey, but not gray leaf spot (*Alternaria brassicae* (Berk.) Sacc.), turnip mosaic virus, imported cabbageworm, cabbage looper, or the nematode *Heterodera schachtii* A. Schmidt. The earthworm, *Lumbricus terrestris* L., was killed by benomyl at 23 ppm ai in soil.

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Ottawa, Ontario

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²Seconded from Animal Diseases Research Institute, February 1974 to December 1974.

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⁴On transfer of work at North Carolina State University, Raleigh, N.C., July 1974 to July 1975.

⁵Appointed May 1974.

⁶Appointed June 1974.

INTRODUCTION

The Animal Research Institute was honored in 1974 in that two of its senior scientists received major awards for their research. Drs. Jenkins and Hidiroglou both received awards for their studies of selenium metabolism and utilization, and the prevention of nutritional muscular dystrophy in ruminants. This research project of the Institute is now almost completed and the trace mineral program team will now investigate problems associated with the requirements of ruminants for the trace elements zinc, copper, and manganese.

The swine nutrition program team began studies on artificial rearing of newborn piglets, and the poultry nutrition program team started research on the biological availability of amino acids from cereal grains. The Institute's pollution program was strengthened by the addition of a full-time scientist to investigate the problems of farm animal wastes and environmental pollution. This program will develop models of animal waste management systems for large integrated farms.

The development of specialized facilities for animal research continued at the Institute's Greenbelt Farm. A building was completed for surgery and radioisotope studies with livestock, and it also provides space for post-mortem examinations and carcass incineration. The construction of two large horizontal silos has made it possible to start investigations into the practical use of this type of silo for forage conservation in an intensive livestock production system.

In cooperation with the Radio and Television Unit, Information Division, Agriculture Canada, two 30-minute, 16-mm, color films with sound tracks were produced to describe the research programs on dairy cattle and sheep production and the Greenbelt research facilities that house these programs. The films, entitled "Dairy cattle breeding and production program" and "Sheep breeding and production program and related research," are available on loan in either English or French from the Information Division, Agriculture Canada.

This report records only the highlights of our accomplishments in 1974; more detailed information can be obtained from the publications listed at the end of the report. Reprints of the research publications and copies of this report are available on request from Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

ANIMAL AND POULTRY BREEDING

Poultry

Genetic resistance to Marek's disease. Research on Marek's disease (MD) continued in cooperation with the Animal Diseases Research Institute, Ottawa.

The response of chickens to challenge with the MD tumor transplant JM-V was studied in several experiments. The size of tumors produced by an injection of JM-V into the wing web was affected both by the genotype of the bird and by vaccination with turkey herpesvirus before challenge with JM-V. Differences between the genotypes on the basis of tumor size were not large enough, however, for this technique to be recommended as a test for genetic resistance to MD. Genotypes also differed significantly in

early mortality after challenge of day-old chicks with JM-V. In a test involving 40 inbred lines, no correlation existed between resistance to JM-V and resistance to virulent MD virus, which indicates that two different genetic mechanisms may be involved. Challenge with JM-V appears to provide a rapid method for detecting immunity resulting from vaccination with turkey herpesvirus. Because differential response of genotypes to vaccination was observed, vaccines should be tested consistently on chickens of the same strain to permit valid comparisons of the results.

Since February 1972 there has been no evidence of MD in the Institute's isolation facility, which provides filtered air and positive pressure (FAPP), even though MD was enzootic in other flocks of the farm. FAPP houses can therefore be recommended

for production of MD antibody-free chicks for experimental purposes.

Cooperative research was conducted with the University of Alberta in developing an *in ovo* test for resistance to MD. The studies implied that hereditary differences in adult susceptibility to MD are related to differential infectivity, or cellular response, or both, that can be demonstrated in the embryo. When eggs from the flock housed under FAPP conditions were used, it was also found that results of this test are not influenced by the presence of maternal MD antibody in the embryo.

Eggshell quality and carbonic anhydrase. A study was made of the relationship between eggshell quality as measured by specific gravity of eggs and the presence of carbonic anhydrase (CA), the enzyme responsible for supplying carbonate ions for shell formation. Two groups of 20 hens, one group laying eggs of low specific gravity and the other, eggs of high specific gravity (measured at 450 days of age), were selected from each of six Leghorn strains. Analysis of their oviducts revealed five CA isozymes in the uterus and magnum, but only four in the isthmus. Sera contained two CA isozymes, both of which were found in each of the three regions of the oviduct. Sera from five hens with inactive ovaries contained at least one additional isozyme. No apparent differences in the presence of isozymes were observed between the groups that laid high- and low-specific-gravity eggs.

Long-term selection for increased egg production. This project was started in 1950 to compare long-term selection response and selection limits in strains with narrow (strain 3) and broad (strain 4) genetic bases. An unselected control strain, identical in origin with strain 3, was also maintained throughout the project. Production per housed hen for the full test year at the beginning of the project was 196 eggs for strain 3 and 157 eggs for strain 4. The primary selection criterion was the number of eggs produced from time of housing to 273 days of age, but the production was recorded for a full test year (to 497 days of age). Other traits were later added to the selection criteria to maintain a bird with commercially acceptable characteristics such as fertility, livability, and egg size. Management practices were changed from time to time to reflect changes in commercial practice.

Data from the project were analyzed up to and including those from birds hatched in 1972. The improvement in egg production per housed hen to 273 days was 33.4 eggs for strain 3 and 43.1 eggs for strain 4. This was accompanied by a reduction in average age at first egg of 31.1 days in strain 3 and 26.9 days in strain 4. The gain in the egg production per housed hen for the whole year was only 34.1 eggs for strain 3 compared with 86.4 eggs for strain 4; however, most of the gain in strain 4 (61.8 eggs) was achieved in the first five generations. Because mortality in strain 4 was lower than in strain 3, performance based on data from surviving hens was similar for both strains.

Genetic parameters of egg production and related traits were estimated year by year for the two strains. In general, estimated heritability of the various traits declined up to 1964. The estimates increased markedly starting in 1965, which coincided with a change in the housing environment of the adult birds, from floor pens to individual cages. Subsequent effects of this change were obscured by a high incidence of Marek's disease in 1969 and 1970, which was accompanied by another sharp increase in heritability estimates. Although the birds have been protected from this disease by vaccination since 1971, estimates from another year or two will be required before it is clear whether heritability is changing.

Dairy Cattle

Field test of Finnish Ayrshires. A comparison of proven Finnish, proven Canadian, and young Canadian Ayrshire sires is continuing in cooperation with 60 breeders of registered Ayrshires in Quebec and Ontario. All matings have been completed and heifers are approaching breeding age. Preliminary studies of meat production conducted in cooperation with Macdonald College of McGill University on 75 male calves from the project indicated that progeny of Canadian sires gain better than progeny of Finnish sires, by 0.05 kg/day.

Evaluation of selection and crossbreeding. Two pure lines of dairy cattle are being established, one Holstein (H) and the other a synthetic (A) line consisting mainly of Canadian Ayrshire with the addition of Brown Swiss, Norwegian Red, and Finnish Ayrshire genes. A crossbred line (C) from the two pure lines will be used for an evaluation of

heterosis on the basis of protein production, longevity, and reproductive performance. Research Branch establishments at Lethbridge, Alta., Charlottetown, P.E.I., Lennoxville, Que., and Normandin, Que., are cooperating in the project. The first C-line cows have begun to lactate. In late 1974, more than 1,500 females were taking part in the experiment at the five locations, 911 H line, 612 A line, and 15 C line, all of which are young stock. Matings with semen from foreign bulls were completed. Female calves born in 1974 totaled 155.

Sheep

New strains development program. After the successful termination of a 3-yr quarantine, four Ile de France rams and the progenies of Ile de France and East Friesian rams were moved and integrated into the main breeding flock. Three populations, each of 40 rams and 480 ewes, will be kept in total-confinement barns. One population will consist of a sire strain selected for muscle growth and the other two of dam strains selected for prolificacy and growth. Ability of females to breed at 6- to 8-mo intervals will be a criterion of selection in each of the three strains. The sire strain will have Ile de France, Suffolk, and Leicester genes, with lesser contributions from the Lincoln, North Country Cheviot, Southdown, Shropshire, Romnelet, and Corriedale breeds. The two dam strains will each carry about 50% Finnish Landrace genes. In addition, one will have mainly Shropshire and Suffolk genes, and the other, Dorset Horn and East Friesian genes with smaller contributions from the Leicester, North Country Cheviot, Shropshire, Suffolk, Romnelet, and Corriedale breeds. Two purebred populations, one Suffolk and the other Finnish Landrace, with 40 rams and 80 ewes in each, will be kept as random-bred control strains to help interpret trends in the performance of the selected strains. The five populations housed in total confinement will provide replacements for a 400-ewe population in conventional barns. Three-way-cross lambs of the sire strain and two dam strains will be produced in this flock for use by other research programs. Other major research activities related to the sheep production system are reported under "Reproductive Physiology" and "Ruminant Nutrition."

MONOGASTRIC NUTRITION

Poultry

Insoluble grit for replacement pullets. Ten strains or strain crosses were reared to 20 wk of age with or without access to insoluble granite grit. No major differences in mortality, weight gain, or feed consumption were associated with the availability of grit.

Phosphorus requirement of laying hens. Eleven strains or strain crosses were fed 0.40, 0.45, 0.50, or 0.55% of available phosphorus in a laying diet. After 20 wk of laying there were no effects on egg production, feed efficiency, mortality, or egg quality.

Growth restriction of broiler breeder stock. Over a 49-wk laying period, hens of two strains reared on a 14% protein diet from 0 to 20 or 2 to 20 wk of age laid more eggs, used less feed per egg, and produced smaller eggs than a control group that received an 18% protein diet from 0 to 6 wk and a 14% protein diet from 6 to 20 wk. In all three rearing regimes, birds were fed on alternate days from 6 to 20 wk. Mortality was highest in the group fed 14% protein from hatching. Birds fed 14% protein from 0 to 6 wk followed by rye ad lib. from 6 to 20 wk had the lowest egg production, poorest feed efficiency, smallest eggs, and highest mortality. The strains differed in mortality and feed efficiency.

In another experiment, the addition of urea at up to 150 g/kg of diet had no effect on gross feed intake of chicks but caused a decrease in body-weight gain, probably because its effect was to dilute the ration. It is not feasible to use urea to restrict the growth of replacement pullets.

Measurement of metabolizable energy. The variation in metabolizable energy (ME) of the diet was measured and partitioned according to bird, day, and acclimatization to dietary change. The results make it possible to design ME assays with the sensitivity required to detect differences of a predetermined magnitude. It was shown that the standard deviation of an ME value increases in a curvilinear manner as the level of inclusion of the test material in the diet decreases.

The ME values of cereal grains were measured with adult roosters. In dry matter of wheat (25 samples), barley (39 samples), and oats (28 samples), ME values ranged

from 11.7 to 15.5, 9.9 to 14.5, and 9.6 to 16.2 kJ/g (2.80 to 3.70, 2.36 to 3.47, and 2.33 to 3.88 kcal/g). Hull-less and high-fat oats had particularly high ME values.

It was shown that the observed ME value measured with adult roosters is reduced when the energy intake is less than the maintenance requirement.

Swine

Artificial rearing of neonatal piglets. Piglets were collected at birth and reared in individual cages in a temperature-controlled room, the air supply for which was drawn from the adult pig area. To simulate the immunological protection that piglets normally receive from the colostrum and subsequent milk, a serum-derived porcine globulin, prepared from slaughterhouse blood, was fed in the milk replacer for the first 10 days of life. Globulin was administered at two levels, either (1) 6.5 g/kg body weight (BW) on day 1, followed by 1.3 g/kg BW on days 2–10, or (2) 10 g/kg BW on day 1 followed by 2 g/kg BW on days 2–10. A negative control (no globulin) was also included, and survival to 3 wk of age was 10% for the control group, 47% for the first test group, and 70% for the second test group.

Glycogen reserves at birth and their rates of depletion. Sows were fed either 0.45 or 2.28 kg feed/day from the 100th day of gestation, to determine whether the glycogen reserves of the piglets at birth, or their rate of use, or both, could be influenced by the nutrient intake of the sow during this period of maximum fetal growth. Dietary treatment did not significantly influence the levels of glycogen in liver or muscle of piglets at birth or at any time during the subsequent 96 h. There was considerable variation between individual piglets, both within and between litters, in their glycogen reserves and the rates of depletion. Average glycogen contents as percentages of wet tissue, at birth and at 6, 12, 24, 48, and 96 h, were 13.2, 8.5, 3.4, 2.4, 3.2, and 3.8 in liver and 9.7, 6.8, 5.6, 4.5, 3.0, and 2.2 in muscle.

Age at puberty in gilts. Control gilts were fed ad lib. a corn-soybean diet (group 1), and others received equal but limited amounts of a basal corn diet (group 2), the basal diet plus lysine (group 3), or the corn-soybean diet (group 4). The control gilts were younger and heavier at puberty than the

other groups. The uteri and ovaries from gilts of both groups fed the corn-soybean diets were heavier (dry weight) than those from gilts fed the basal diet. Uteri contained about 15% dry matter, of which 3.5–4.0% was fat. The mean weights of nitrogen, fat, and ash in the uterus of gilts from groups 1 to 4 were 10.6, 7.9, 9.4, and 10.1 g nitrogen; 2.6, 2.2, 2.5, and 2.5 g fat; and 4.9, 3.7, 4.4, and 4.9 g ash. Uterine fatty acid composition (%) was: C₁₆, 19.4; C_{16:1}, 2.7; C_{18:1}, 26.8; C_{18:2}, 7.9; and C_{20:4}, 12.0.

REPRODUCTIVE PHYSIOLOGY

Hormones in Body Fluids and Tissues

Steroid identification. A method has been developed for identification of neutral steroids in body fluids and tissues, based on the correlation of retention time by gas-liquid chromatography with steroid structure. Its reliability has been improved by further synthesis of commercially unavailable steroids and study of their properties by gas-liquid and thin-layer chromatography.

Hormone levels in plasma. The changes in plasma levels of estrone sulfate, estrone, and estradiol (estradiol-17 α plus estradiol-17 β) have been determined by radioimmunoassay in plasma samples taken twice daily from four cows around the time of parturition. The plasma levels of estrone sulfate ranged from 5.0 to 24.0 ng/ml around the time of parturition, whereas the levels of estrone and estradiol were approximately equal and ranged from 1.0 to 2.0 ng/ml. The plasma levels of all the estrogens dropped rapidly to nondetectable levels within 24 h after parturition. The significance of this high plasma level of estrone sulfate at the time of parturition is not yet apparent, but a similar pattern has also been observed in the ewe and the sow.

A reliable early pregnancy test for pigs has been established. A positive diagnosis of pregnancy is recorded if estrone sulfate can be detected in a single plasma sample taken 20–30 days after breeding.

Cattle

Post-partum ovarian activity in cattle. In collaboration with the University of Guelph, ovarian activity in a group of 70 post-partum dairy cows was monitored by sequential determination of plasma progesterone from

10 to 60 days post-partum and the results were correlated with the occurrence of behavioral estrus. The cows were equally distributed between free-stall and tie-stall systems of management. Behavioral estrus was monitored continuously in the free-stall group with a time-lapse video recorder, whereas, in the tie-stall group, estrus was detected by conventional management procedures. Close agreement was observed between a sharp depression in the concentration of plasma progesterone and the occurrence of estrus in free-stall animals. In the tie-stall group, although similar sharp depressions in progesterone concentrations occurred at fairly regular intervals, estrus was not always reported. Ovarian function was similar in the two groups but estrus detection was enhanced significantly in the free-stall group by continuous monitoring.

Synchronization of the estrus cycle in cattle. A field trial has been conducted in collaboration with the University of Guelph to evaluate the use of two injections, each consisting of 30 mg of prostaglandin $F_{2\alpha}$ tromethamine salt, administered 10 days apart, to synchronize estrus. Of the 30 randomly cycling heifers treated, 83% showed estrus 2-4 days after the second injection. Out of 15 control heifers, 13 (87%) were detected in estrus over a 3-wk period. Both treated and control groups were bred by artificial insemination during estrus, and their pregnancy rates were similar. This two-injection system may have commercial application in the controlled breeding of cattle.

Sheep

Controlled breeding program for increasing sheep production. A controlled breeding program has been established for the genetics breeding flock to increase reproductive potential and efficiency of lamb production. The breeding flock, which will ultimately comprise 2,000 ewes, has been divided into two groups (A and B). Each group is being bred every 8 mo, with one group starting 4 mo after the other. The breeding is done in January, May, and September. During the anestrous season of May, estrus is induced by the use of vaginal sponges impregnated with 30 mg fluorogestone acetate (FGA) (Chronogest; Laboratoire Searle, Département Vétérinaire, Paris, France) and pregnant mares' serum gonadotrophin (PMSG). During the estrous season (January and September

breedings), estrus is synchronized by the use of vaginal sponges impregnated with 40 mg FGA and PMSG. Artificial insemination is used for breeding and is compared with natural mating. A controlled daily light regimen, consisting of 18 h light: 6 h dark for 4 mo during breeding and early gestation and 10 h light: 14 h dark for 4 mo during late gestation and after parturition, is used to induce estrous cyclicity. Ewe lambs incorporated into the breeding groups are bred at 7 mo of age and estrus is induced by use of small vaginal sponges impregnated with 40 mg FGA and PMSG.

This program began in May 1974, and to date each group has been bred once, group A in May 1974 and group B in September 1974. As data are accumulated from successive breedings and lambings, each of the experimental components will be evaluated in terms of its effectiveness and contribution to the efficiency of the system.

Three other light regimens are being evaluated for their ability to induce estrous cyclicity in ewes: a continuous regimen of 10 h light: 14 h dark, a normal annual light cycle contracted to 8 mo, and a normal annual light cycle contracted to 8 mo but 4 mo out of phase with the other cycle.

Methods for collection, extension, and long-term storage of ram semen, and for assessment of semen quality, are being developed and evaluated.

Biorhythms. Body temperatures of a group of sheep were recorded continuously for 17 days. Time series analysis of the data (correlogram, periodogram, and power spectrum) revealed a periodicity of approximately 24 h. The intensity of the biorhythm varied between animals. Periodicities of more and less than 24 h were also evident. In another study, eating and resting activities and body temperature were recorded in a group of sheep under a light regimen of 12 h light: 12 h dark for 26 days. The hours of light and darkness were then reversed for 21 days, and reversed again for 19 days. Chronogram plots revealed a fairly definite biorhythmic pattern of eating activity which was reversed within 48 h of change in the light regimen. Little or no biorhythmic pattern was discernible in drinking activity. Body temperature data are now being analyzed.

Swine

Factors that control follicular development and ovulation. In collaboration with Macdonald College of McGill University, and the University of Western Ontario, investigations are under way on the role of prostaglandins in the events leading to ovulation. The prepuberal pig, treated with pregnant mares' serum gonadotrophin and human chorionic gonadotrophin to induce ovulation, is being used as an experimental model. Preliminary results have indicated that the prostaglandin F content of fluid in preovulatory follicles increased markedly 10–12 h before ovulation. These data support the hypothesis that prostaglandins are involved in the process of ovulation in the pig.

Induction of parturition in swine. Various levels of prostaglandin $F_{2\alpha}$ tromethamine salt were given to sows and gilts as a single intramuscular injection between the 111th and 113th days of pregnancy, to induce farrowing. Over the range of dosage (0.25–2.0 mg/10 kg body weight), parturition was induced in 70% of 41 animals. Mean time to the start of farrowing was $27.0 \text{ h} \pm 4.2$ (S.D.). The only apparent difference between treatments was a lower proportion (43%) of successfully induced parturitions in pigs treated on the 111th day. Pigs in which parturition was not induced commenced farrowing 2–6 days after the injection. In a control group the average length of gestation was 116 days. Parturition, lactation, and growth of piglets were normal.

RUMINANT NUTRITION

Beef Cattle

Economic systems of beef production in the Northern Claybelt. At Kapuskasing, Ont., five groups of Shorthorn cows bred to Limousin sires to calve in the spring were wintered in an insulated, unheated barn. All groups were fed grass silage treated with formic acid at the daily rate of 1.7 kg dry matter/100 kg initial weight. During the summer one group of cows and their calves remained confined in the barn and the cows were full-fed grass silage treated with formic acid; the other four groups were assigned to four pasture treatments. All groups of calves were weaned in late September.

The average daily weight changes of the confined animals from June 4 to weaning

were –0.17 kg for cows and 0.81 kg for calves. For those on unrenovated unrotated, unrenovated rotated, renovated unrotated, and renovated rotated pasture, the weight changes of cows were –0.05, +0.10, +0.12, and +0.31 kg and weight changes of calves were 1.04, 1.06, 1.13, and 1.15 kg.

Shorthorn \times Limousin steers and heifers were marketed after a 322-day feeding period on grass silage and high-moisture barley treated with propionic acid. They were graded 89% A1 and 11% B1, which indicates that cattle can be finished satisfactorily in the Northern Claybelt on locally grown feeds.

Electronic feeding gates for Holstein steers. Steers were housed loose and fed individually by use of an electronically controlled feeding gate, and their growth and feed efficiency were compared with those of similar animals tied continuously during the 420-day feeding period. There was little difference between loose and tied animals in average daily gain (ADG) or feed efficiency (1.08 and 1.02 kg ADG, and 6.7 and 6.8 kg feed/kg gain) when an all-concentrate diet was fed. When the steers were fed a concentrate ration to which 40% ground high-quality alfalfa was added, ADG was 1.04 kg for loose-housed but only 0.94 kg for tied steers; feed efficiency also declined, to 8.71 and 9.51 kg feed/kg gain for loose and tied steers.

Dairy Cattle

Dry matter content, density, and losses of ensiled corn. A tower silo 9.1 m in diam and 24.4 m high was filled in 3 consecutive yr with corn at different dry matter contents (28, 33, and 45%). The density of the settled silage was much higher when dry matter content was low (880 kg/m^3) than when material was drier (560 kg/m^3). The quantity of dry matter stored was the same each year, around 410 tonnes (t). Dry matter losses were low each year, ranging from 8.8% for the silage ensiled at 33% dry matter to 13.6% for the silage ensiled at 45% dry matter. These larger losses were probably caused by heating of the silage, which apparently occurred even if the silos were emptied fairly rapidly (at least 15 cm/day). The amount of liquid runoff was significant in only one silage, but the low losses of dry matter observed that year (9.2%) indicate that effluent is not always the main cause of dry matter loss.

Ratios of corn to alfalfa silage in rations for lactating cows. Alfalfa was cut at the bud stage and ensiled with 90% formic acid at 3.7 kg/t. The silage was fed to cows in various combinations with corn silage, to comprise 0, 33, 67, or 100% of the forage dry matter. The protein contents of the rations were equalized by addition of a concentrate mixture that complemented the protein content of the forages fed. Dry matter consumption of all rations was the same; however, milk production definitely tended to increase as quantities of alfalfa silage in the ration increased. Daily milk yield was 17.5, 18.7, 19.7, and 20.1 kg for cows on diets containing 0, 33, 67, and 100% alfalfa silage. The quantities of protein supplied in the concentrate mixture were 25, 20, 14, and 8% for the four diets in the same order; this indicates the financial benefits from judicious use of legumes as forages.

Hormone assays. Antibodies were made to the hormones prolactin, triiodothyronine, and thyroxine, as well as precipitating antibodies for double antibody radioimmunoassay. Purified hormones were labeled with radioactive iodine, and radioimmunoassay techniques for the detection of these hormones have been developed.

Response to intravenous infusion of lysine, methionine, and carnitine. Four lactating Holstein cows were each infused intravenously for periods of 10 days with solutions of L-lysine (15 g/day), L-lysine plus D,L-methionine (15 + 10 g/day), D,L-carnitine (20 g/day), or saline. The cows were fed a basic ration of 2 kg chopped hay, corn silage ad lib., and a concentrate mixture (16.5% crude protein) at 1 kg/3 kg milk. Infusion treatment had no effect on intake of corn silage, yield and composition of milk, or digestibility of the ration. The efficiencies with which dietary protein was converted to milk protein were 38.4, 38.6, 36.6, and 37.8%, and nitrogen balances were 6, -2, 8, and 5 g/day for cows that received the saline, lysine, lysine plus methionine, and carnitine treatments. Infusion of carnitine resulted in a greater concentration of carnitine in the milk than did other treatments; however, it had no apparent effect on the plasma levels of amino acids, even methionine and lysine, which are known precursors of this compound. Infusion of methionine was reflected by an increase in plasma levels of methionine, but infusion of lysine elicited only a slight increase in plasma lysine levels.

This result suggests that, under the conditions of this experiment, lysine was limiting but methionine was not.

Amino acid synthesis in rumen bacteria. Mixed rumen microorganisms, maintained in continuous culture, readily incorporated labeled HCO_3^- and acetate into amino acids. Labeled propionate, in contrast, was used only for biosynthesis of isoleucine and failed to label other amino acids to any significant extent. In these mixed (symbiotic) cultures, forward citrate cycle reactions only proceeded as far as 2-oxoglutarate. ^{14}C distribution in amino acids clearly showed that 2-oxoglutarate was not oxidized further by citrate cycle enzymes. Acetate was carboxylated to pyruvate, which was then carboxylated to oxalacetate, which in turn was converted to aspartic acid. Evidence was also obtained that propionate was carboxylated to 2-ketobutyrate, isovalerate to 2-ketoisocaproate, phenylacetate and hydroxyphenylacetate to the corresponding phenyl- and hydroxyphenyl pyruvic acids, and succinate to 2-oxoglutarate. Of the amino acid precursors investigated, only 3-hydroxypyruvate, the precursor of serine, appeared to be synthesized through an oxidative step, that is, 3-phosphoglyceric acid to 3-phosphohydroxypyruvic acid. Most 2-keto precursors of amino acids in these organisms appear to be formed through reductive carboxylation of the precursor acid.

Urease activity in rumen bacteria. Unlike Jack-bean urease, rumen urease has never been purified successfully because of the extremely unstable nature of the enzyme. Rumen urease was successfully solubilized in stable form. When all the steps were carried out in the presence of 50 mm of Cleland's reagent, about 25% of the yield of solubilized enzyme was purified, with a specific activity of 1200-1500 μ moles urea hydrolyzed/mg protein per h. This purification is 300- to 350-fold better than that obtained in the bacterial suspension. A procedure was developed for the detection of urease activity on polyacrylamide gels. It was found by this procedure that the molecular weight of rumen urease is much lower than that of Jack-bean urease. Further, the results indicate that only one type of urease (or ureases with identical electrophoretic mobilities and molecular weights) is produced in the rumen, although many organisms are known to produce the enzyme.

Sheep

Intensive rearing of lambs. A total of 1,230 lambs were weaned from milk replacer with an overall ADG of 253 g. Overall mortality while on milk replacer was 10.7%. Lambs fed milk replacer containing 24% fat had ADG and survival rates equal to, or better than, those fed milk replacer containing 30% fat.

In post-weaning experiments, lambs on a daily light regimen of 18 h light: 6 h dark gained more rapidly than those on 10 h light: 14 h dark. When vitamin D levels, trace mineral supplements, or Ca:P ratios were adjusted, the incidence of crooked legs among animals in the intensive sheep production system was not greatly reduced, if at all. However, when Ca:P ratio was adjusted from 1:1 to 2:1 there was a tendency toward higher ADG.

Nutritional Value of Rapeseed Oil

Triglycerides were isolated from oil of the rape (*Brassica campestris*) cultivar Span by molecular distillation and adsorption chromatography. These triglycerides contained no measurable sterol contamination, as judged by thin-layer and gas-liquid chromatography. Male rats fed the triglyceride fractions for 16 wk developed necrotic and fibrotic lesions in the hearts identical with those found in rats fed the fully refined rapeseed oil from which the triglycerides were isolated. Thus, the pathogenicity of rapeseed oil can apparently be attributed to the triglycerides and not to any other trace constituent(s) of the oil.

The nutritional, biochemical, and histopathological properties of oil from two new *Brassica campestris* cultivars, Zephyr (0.6% erucic acid) and Field Tower (1.8% erucic acid), were studied. Sixty-five percent of rats fed Zephyr and 75% of rats fed Tower showed evidence of myocardial necrosis and fibrosis at 16 wk.

In a number of experiments it has been observed that male rats fed fully refined rapeseed oil containing low (0.6%), intermediate (5%), or high (23%) erucic acid levels developed symptoms similar to those described in the case of an essential-fatty-acid deficiency. Electrocardiogram recordings were made with rats fed a 5% or 20% corn oil diet, a 20% rapeseed oil diet, or a diet without fat (essential fatty acids). Many of the tracings showed evidence of QRS changes, such as deep Q-waves, inverted T,

and possibly S-T changes. These results do not support the suggestion that notching in the QRS complex is a sensitive indicator of essential-fatty-acid deficiency. Preliminary studies with rats fed diets containing rapeseed oil suggest that the capacity of vesicular tissue to produce prostaglandin E₂ is impaired.

Pollution

Nutritive value of silage with liquid manure. Two digestibility trials were conducted with sheep to determine the nutritive value of ensiled mixtures of chopped hay and liquid manure (LM) from ruminants or poultry. A basic mixture consisting of 24% hay, 46% water, and 30% LM was stored in laboratory-sized silos (400 kg capacity), alone (treatment 1), or with 45 kg molasses (treatment 2), or with 45 kg molasses plus 0.45 kg brewer's yeast (treatment 3). In the first trial with ruminant LM, more silage spoiled in treatment 1 than in the other treatments; however, the addition of molasses resulted in an apparent loss of nitrogen during fermentation. For treatments 1, 2, and 3, the protein contents were 14.7, 12.0, and 8.5% and the apparent protein digestibilities were 64, 54, and 44%. In the second trial with poultry LM, spoilage was minimal in all treatments. For treatments 1, 2, and 3, the protein contents were 16.9, 13.9, and 14.9% and the apparent protein digestibilities were 64, 59.4, and 62.7%. Dry matter intakes were greater with ruminant LM than with poultry LM in silage mixtures, but protein digestibility and nitrogen balance were more favorable with poultry LM.

Salmonella sp. in drainage streams and manures. Bacteriological laboratories of Environment Canada conducted a search for *Salmonella* sp. in selected water and feces samples at the Institute's Greenbelt Farm. No *Salmonella* sp. were isolated from 133 feces samples (72 from cattle, 25 from sheep, 22 from hens, and 14 from migratory Canada geese). One-litre aliquots of 12 out of 18 water samples from two drainage stream systems were shown to contain *Salmonella* sp.; 45 isolates were identified biochemically and serologically. It was postulated that native animal and bird populations in the drainage area were the probable source of these enteric pathogens.

TRACE ELEMENTS AND PESTICIDES

Pesticide Residues and Metabolism

Methoxychlor. The metabolism of methoxychlor in poultry is being studied with the use of ring-labeled ^{14}C -methoxychlor. To produce residues in eggs, laying hens were fed a diet containing 100 ppm methoxychlor. Radioactive materials in excreta were separated into four fractions by solvent extraction, and the hexane extract was separated again by column chromatography with use of several solvent mixtures, followed by thin-layer chromatography. The extract contained mainly non-metabolized methoxychlor and the dihydroxylated metabolite, with traces of other metabolites. The identity of metabolites in the other fractions of excreta, eggs, and tissues is being investigated further.

Preliminary in vitro studies have indicated the presence of an enzyme in chicken liver microsomes which degrades methoxychlor to hydroxylated compounds. No metabolites were extractable by hexane. Metabolites in the aqueous phase included two major components tentatively identified as the monohydroxylated and dihydroxylated metabolites. Six minor components were present in trace amounts and have not yet been identified.

Atrazine. In conjunction with the Chemistry and Biology Research Institute, studies were continued on the metabolism of atrazine in laying hens fed 100 ppm atrazine in their diet. Neither atrazine nor hydroxyatrazine was detected in eggs, but both were identified in excreta. Two other compounds had previously been detected in eggs from control hens as well as in eggs and excreta from treated hens. Additional experiments revealed that these were not derived from atrazine, although it had been found previously that their retention times were similar to those of the dealkylated metabolites. Investigations in this area are continuing.

Lindane. In conjunction with the Chemistry and Biology Research Institute, in vitro studies on the metabolism of lindane were resumed. An enzyme, probably a dehydrogenase, which rapidly metabolizes the insecticide was shown to be present in the soluble fraction of chicken liver homogenates. The

major metabolite found after a 5-h incubation was positively identified as γ -pentacyclochlorohexane. At least eight other metabolites in the pentane extract were tentatively identified. Other unidentified metabolites which remained in the aqueous phase are being investigated further.

Trace Elements

Nutritional muscular dystrophy. It has been established that an effective procedure for preventing nutritional muscular dystrophy (NMD) in young ruminants is to include selenium and vitamin E in the mineral premix fed to the dams during pregnancy. Results obtained in 1974 showed that addition of selenium at either 15 or 30 ppm to the mineral mixture fed to beef cattle without vitamin E supplementation did not completely prevent NMD.

Selenium deficiency and reproduction. A collaborative experiment was conducted with the Animal Diseases Research Institute on the effect of selenium deficiency in ewes on the ovulation rate, occurrence of early embryonic death, and lambing percentage. It was found that selenium deficiency did not impair reproductive performance per se. The number of normal embryos and the percentage loss of potential embryos were actually slightly higher for the selenium-supplemented group.

Effect of selenium on methionine metabolism in rumen of sheep. Intraruminally administered methionine labeled with ^{14}C and ^{35}S was incorporated into bacterial and protozoal proteins as intact methionine and as its metabolites, mainly cystine. In the bacterial fraction, the peak of methionine incorporation occurred 2 h after administration of the radioisotopes. More radioactivity was incorporated in the rumen bacteria and tissues of selenium-supplemented sheep than selenium-deficient ones.

Gastrointestinal metabolism of trace elements. Zinc, manganese, selenite, and selenate were all found to be secreted into the gastrointestinal tract of chicks, mainly in the duodenum. Zinc, selenite, and selenate were predominantly protein-bound in the duodenal mucosa whereas manganese occurred free. Bile contained elevated levels of manganese and zinc, and may carry substantial quantities of these elements to the gastrointestinal tract by this means.

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Aphelenchoidea

Homoptera: Cicadellidae

Hemiptera: Corixidae

Hemiptera: Miridae, Anthocoridae

Nematoda: Heteroderidae,

Tylenchidae

Homoptera: Aphidoidea,

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Coleoptera: Staphylinidae,

Alleculidae

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Arachnida: Acarina

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Staphylinidae

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 Euphorinae

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 Evanioidea, Sphecoidea

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Chalcidoidea

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Ichneumonidae

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Chalcidoidea, Cynipoidea

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Trichoptera

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 including Fungi Imperfecti

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Pyrenomycetes on woody plants

J. H. GINNS, B.S., M.S., Ph.D.

Wood-inhabiting Hymenomycetes

S. J. HUGHES, B.Sc., M.Sc., D.Sc., F.L.S., F.R.S.C.

Fungi Imperfecti, Hyphomycetes

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Polyporaceae, Tremellales,
 Hydnaceae

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Agaricales

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Wood-inhabiting Hyphomycetes

L. K. WERESUB (Miss), B.A., M.A., Ph.D.

Thelephoraceae and Hydnaceae

Plant Disease Fungi

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Departures

R. ROY

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D. B. O. SAVILE, B.S.A., M.Sc., Ph.D., F.R.S.C.

Uredinales

Retired July 1974

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INTRODUCTION

During the year a special effort was made to realign Institute activities with systematic studies of the north temperate fauna and flora. Particular emphasis was placed on research on organisms of economic importance.

The Biosystematics Research Institute provides a National Identification Service for Canada on fungi, vascular plants, insects, arachnids, and nematodes. To meet this responsibility, the Institute conducts research on various aspects of biosystematics and maintains custody of the National Mycological Herbarium, the Agriculture Canada Vascular Plant Herbarium, and the Canadian National Collection of Insects, Arachnids, and Nematodes.

The Mycology Section of the Institute was reorganized into two new sections: Biodegrading Fungi and Plant Disease Fungi. The new titles reflect better the programs of our mycologists.

The terms of the following three Section Heads terminated during 1974: Dr. J. F. McAlpine (Diptera), Dr. E. H. Salkeld (Experimental Taxonomy), and Dr. R. A. Shoemaker (Plant Disease Fungi).

Reprints of research publications are available from the authors. Correspondence should be addressed to Director, Biosystematics Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

D. F. Hardwick
Director

THE NATIONAL IDENTIFICATION SERVICE

The demand for identification of material continued at a high rate. During the year, 1532 shipments of material containing more than 211,800 specimens were received for identification. The amount of material from Agriculture Canada continued to increase; more than 53,380 specimens were received from the research stations (25% of the total submissions). Environment Canada was the principal user of the service, submitting 101,400 specimens (50%), a considerable decrease due to a dwindling of the Mackenzie River pipeline survey. The amount of material from Canadian universities continued as in previous years with 25,300 specimens received (11%). More material was submitted by amateurs, private individuals, hospitals, and health units with some 5000 specimens received from across Canada. Agencies outside Canada submitted 21,880 specimens, an increase over previous years. More than 184,700 specimens of nematodes, arthropods, plants, and fungi were identified and returned. Most of the insect material was from the Mackenzie River Pipeline Survey, which is nearing completion. The accompanying tables show the number of specimens

identified, their sources, and the distribution within the group.

COLLECTIONS

The holdings of Institute collections increased by some 360,000 specimens of nematodes, arthropods, plants, and fungi during the year. Staff members collected more than 210,000 specimens, about 100,000 specimens were donated, and the rest were bought. The accessions in the National Mycological Herbarium total 194,800 specimens and the holdings of the National Culture Collection are 11,600 cultures, of which 900 have been successfully lyophilized for long-term storage. The W. L. Gordon Mycological Collection of over 7000 specimens with an extensive card file was transferred to the Institute from the Research Station, Winnipeg, Man. Donations to the collection included 275 cultures of Nidulariaceae (bird's-nest fungi) from Dr. H. J. Brodie, University of Alberta, and a large collection (611 specimens) of wood-rotting fungi (Thelephoraceae and Hydnaceae) from northern India by Dr. S. S. Rattan, Panjab University, India.

Incorporation of material into the collection continued: 284,000 specimens of insects,

arachnids, and nematodes; 5400 vascular plants; 2900 fungi; and 300 cultures. Loans from the Collections to scientists throughout the world totaled 205 shipments comprising 44,600 insects and arachnids, 531 specimens of fungi, and 6834 herbarium sheets of vascular plants.

FIELD STUDIES, FAUNAL SURVEYS, AND MUSEUM VISITS

Field studies were conducted by 32 officers for about 70 man-weeks in various parts of Canada and USA with the main concentration of effort in Ontario and Western Canada. Dr. S. J. Hughes spent 9 wk in Recife, Brazil, collecting and studying types. The most noteworthy collections were 20,000 Coleoptera from southwestern USA and British Columbia, 4000 Lepidoptera (cutworm moth survey) from the west coast of Canada and USA, 15,000 pieces of amber from Alberta, 10,000 Homoptera and 35,000 Acarina from southern Ontario, and 3000 Lepidoptera and 5000 Hymenoptera from the Maritime Provinces. Collections (1700 herbarium sheets) of vascular plants were made in various parts of Canada and 545 mycological collections were made primarily in Ontario and adjacent USA.

Scientists from the Institute visited various museums, universities, and other institutions to study type specimens, type species, and other representatives of groups on which they are working. Two scientists visited major museums in Europe, nine visited U.S. museums and major collections at U.S. universities, and eight visited collections at Canadian universities and provincial museums.

Many scientists and students from various countries (Canada, USA, Australia, Chile, Brazil, Hawaii, Finland, Poland, Switzerland, and Scotland) visited the Institute Collections to study material. Some of our interesting visitors included Dr. J. W. Carmichael, University of Alberta, to study Hyphomycetes; Mr. D. K. Mardon, University of Aberdeen, to study Siphonaptera of Australia and New Guinea; Dr. Cleide Costa, Museo Sao Paulo, to study Elateridae; Dr. Donald Colless, CSIRO, Canberra, to study Mycetophilidae; Mr. J. Klimaszewski, Wrocław University, Poland, to study Staphylinidae.

Number of plants identified, Nov. 1, 1973 – Oct. 31, 1974

Canada	
Agriculture Canada	1,063
Environment Canada	1,836
Other federal departments	714
Provincial departments	574
Industry	7
Universities	435
Private inquiries	805
USA	
Universities	46
Other countries	747
Total	6,227

RESEARCH

Biodegrading Fungi

Taxonomy. The first detailed survey of rhizina root rot in North America was carried out and its geographic distribution, host range, seasonal occurrence, and pathogenicity were determined. A long-established and much confused North American fungus was recognized as a new genus, *Graphostroma* Piroz., and comparisons were made with the European *Xenotropa* Petrak, a species only recently discovered in North America. An unusual fungus imperfectus was isolated from blueberries in Quebec. It was investigated jointly with researchers at the universities of Laval and Guelph and recognized as a member of an undescribed genus. A popular publication on the morphology, distribution, occurrence, collection, and preparation of morels in Canada was completed and will soon be available. Continuing studies on sooty molds, using new and original morphological and ontogenetic approaches, resulted in elucidation of *Euantennaria* Speg. with *Antennatula* Fr. and *Hormisciomycetes* Bat. & Nasc. imperfect states, and the new species *Capnobotrys* Hughes.

Fungi Canadenses. Studies on native fungi resulted in the addition to the series of a further 27 items, comprising biodegrading, mycorrhizal, and parasitic species, and including a new genus, *Connersia* Malloch.

Number of insects, arachnids, and nematodes identified, Nov. 1, 1973 — Oct. 31, 1974

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonaptera	Other insects	Acarina	Other arthropods	Araneida	Nematoda	Total
Canada													
Agriculture Canada	912	3,061	315	1,295	2,115	1,866	61	791	365	—	991	7,201	18,973
Environment Canada	1,032	70,879	26	2,700	6,932	514	—	22,608	686	2	15	2,565	107,959
Other federal departments	2,251	1,153	1	1,387	385	1,327	—	2,347	—	—	1,014	—	9,865
Provincial departments	541	165	17	97	409	355	—	74	50	206	32	—	1,946
Industry	9	—	—	—	1	—	—	—	—	—	—	—	10
Universities	1,462	11,825	408	837	1,308	837	29	802	982	32	188	125	18,835
Private inquiries	1,868	182	93	618	258	205	20	1,133	154	51	6	—	4,588
USA													
Government departments	81	126	291	—	689	159	430	—	153	—	—	—	1,929
Universities	1,212	923	2,279	—	399	1,157	—	4	379	—	337	—	6,690
Private inquiries	667	41	—	—	—	134	—	—	1	—	127	—	970
Industry	—	—	—	—	—	—	15	—	—	—	—	—	15
Other countries	120	481	—	2	4,980	37	—	—	103	—	—	—	5,723
Total	10,155	88,836	3,430	6,936	17,476	6,591	555	27,759	2,873	291	2,710	9,891	177,503

Number of mycological collections and cultures identified, Nov. 1, 1973 – Oct. 31, 1974

	Agaricales		Aphyllophorales		Discomycetes		Erysiphales		Hyphomycetes		Phomales and Melanconiales		Phycomycetes		Pyrenomycetes		Rusts and smuts		Other		Total	
	Coll.*	Cult.†	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.	Coll.	Cult.
Canada																						
Agriculture Canada	18	—	27	1	10	1	3	—	18	40	29	13	80	31	52	12	11	—	8	—	256	98
Environment Canada	2	—	92	31	5	1	—	—	6	14	3	—	—	5	11	7	2	—	—	—	121	58
Other federal departments	—	—	3	—	—	—	—	—	2	10	1	2	—	—	1	1	—	—	—	—	7	13
Provincial departments	1	—	—	—	—	—	—	—	—	3	—	2	1	—	—	2	—	—	2	—	4	7
Universities	35	—	61	—	19	—	2	—	13	11	5	11	—	1	18	6	9	—	17	—	179	29
Ottawa Civic Hospital	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Private inquiries	208	—	9	—	5	—	1	—	13	—	—	—	—	—	15	—	8	—	2	11	261	11
USA																						
Government departments	—	—	56	—	—	—	—	—	5	4	—	—	—	—	—	—	—	—	—	—	61	4
Universities	—	—	1	—	1	—	—	—	5	1	2	—	—	—	5	2	1	—	—	—	15	3
Other	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	—	—	—	—	12	—
Other countries	—	—	16	—	17	—	—	—	5	9	—	1	—	—	17	—	12	—	2	—	69	10
Total	265	—	265	32	57	2	6	—	67	92	40	29	81	37	131	30	43	—	31	11	986	233
Total identifications of collections and cultures																						1,219

* The term collection is used to designate a sample of a fungus population. The sample consists of an indefinite number of individuals, ranging from a few in larger fungi to several thousands in microfungi. The term collection is used in contradistinction to specimen, which in zoology and phanerogamic botany is the equivalent of an individual.

† The term culture denotes a living fungus population aseptically cultivated on various substrates under different conditions, usually to obtain identifiable structures or different states in the life cycle.

This name honors I. L. Connors, one of the pioneers of systematic mycology in Canada and a builder of the National Mycological Herbarium.

Other activities. Three important theoretical contributions were formulated: a new point of view on the genetic makeup of basidiomycetes (including biodegrading and mycorrhizal fungi as well as the cultivated mushroom) by postulating that spores may contain two different but noncomplementary nuclei; a hypothesis dealing with fundamental evolutionary advances in plant life by postulating that land plants arose and continue to exist as symbiotic systems involving mycorrhizal fungi; consideration of an aspect of the controversial Art. 59 of the *International code of botanical nomenclature* in order to eliminate a long-standing source of misunderstanding.

Plant Disease Fungi

Ascomycetes. The fifteen species in the genus *Ciborinia* were considered in the critical examination of the six species of *Ciborinia* that occur in Canada. This study comprises examination of the tissue anatomy of sclerotia and apothecia and cultural investigation and production of apothecia under artificial conditions. The species are host specific to *Erythronium*, *Trillium*, *Viola*, *Populus*, and *Salix* and include such pathogens as black rib of willows (*C. foliicola* (Cash & Davidson) Whetz.) and ink spot disease of poplar (*C. whetzellii* (Seav.) Seav.). A completed ultrastructural study of *Venturia inaequalis* (Cke.) Wint. on crab apple described conidium ontogeny and subcuticular host-parasite interrelationship. Generic concepts were revised for a number of genera of parasites of shrubs and trees, such as *Aglaospora*, *Massaria* (= *Saccothecium*), *Spilobolus*, and *Splanchnonema*. In cooperation with J. D. Smith, Research Station, Saskatoon, Sask., *Pithomyces chartarum* (Berk. & Curt.) M. B. Ellis was described from brome grass stubble in Saskatchewan; this fungus produces the hepatotoxin sporidesmin, the cause of liver damage and facial eczema of sheep.

Phycomycetes. A joint study with W. G. Kemp, Research Station, Vineland Station, Ont., on the carrot rusty root problem in the Bradford Marsh, Ont., has shown it is unlikely that either *Pythium sulcatum* Pratt & Mitchell or *Oplidium brassicae* (Woron.)

Dang. alone can cause the disease. A joint study with J. T. Slykhuis, Research Station, Ottawa, on wheat spindle streak mosaic, a virus thought to be fungus transmitted, has shown that four species of zoospore fungi and five *Pythium* spp. are abundant in soils in which winter wheat has been grown. Ultrastructural studies on zoospores have shown a basis for reclassifying the Chytridiales on zoospore type.

Fungi Canadenses. As a contribution to the continuing series *Fungi Canadenses*, 23 native species have been described. These fungi include 14 Basidiomycetes, 2 Coelomycetes, 6 Ascomycetes, and 1 Phycomycete.

Other activities. Work was completed on a contributory chapter on airborne fungus spores for *An atlas of airborne pollen allergens*. Twelve genera in the major fungus groups have been described with comments on their allergenic potential, period and duration of spore dispersal, and illustrated with comparative plates of other fungi.

A staining method for host-parasite interrelationship studies was developed. This method, which employs orseillin BB and crystal violet, differentiates host cytoplasm, nuclei, cell walls, and fungal mycelium. It is equally effective on paraffin sections, cryostat sections, and squash mounts.

Aquatic Biology, Hemiptera, and Nematology

Handbooks. Fifteen genera representing 43 species were analyzed for a handbook of the Anthocoridae (Hemiptera) of Canada and Alaska. For the handbook of prairie Miridae (Hemiptera) 150 illustrations have been completed. Keys, illustrated descriptions, distribution, and plant affiliations have been completed for the Hoplolaimidae and Tylenchorhynchidae (Nematoda) in preparation for a handbook. Work was begun on a handbook of the Cercopidae (Homoptera) of Canada.

Aquatic insects. Preliminary research on the life habits of water mites indicates that midgets (Chironomidae) are their principal host group. Fifty-two genera of Chironomidae were found to be parasitized.

Hemiptera. The revision of the economically important plant bugs of the genus *Lygus* in North America includes notes on distribution, polychromatism, dimorphism,

and biology of 35 species and habitus illustrations of 34 species. Generic reviews of the leafhopper tribes Macropsini, Magnentiini (new tribe), and Aphrodini resulted in 7 new genera, 14 new species, and 3 new nearctic records. The leafhopper subfamily Eurymelinae and the tribes of the Aphrodinae were redefined. A host index containing 2400 species of aphids that have been described since 1935 and 1500 host listings was completed.

Nematology. Illustrated keys and descriptions of the plant parasitic genera of Canada, the species of Paratylenchidae, and the genera and species of parasitic mermithids of the Mackenzie River system are being prepared. The male characters are emphasized, with analysis of their variability under Canadian conditions. The scanning electron microscope is being used in the identification and classification of pathotypes of the cyst-forming nematodes and its results applied in the taxonomy of root-knot nematodes.

Collaboration with other agencies. A collection of 45,000 insects and other arthropods from the National Capital area was identified for the National Museum of Natural Science, Ottawa. A Ph.D. thesis by A. Soponis on *Orthocladus* (s.s.) (Chironomidae) was completed and a postgraduate program with P. Pehlta on chironomid - water mite relationships was begun under the supervision of an Institute scientist. Cooperative studies on the aquatic insects and nematodes of the Mackenzie River system were carried out with Environment Canada. Cooperative studies of variation in root-knot, root-lesion, and gall-forming nematodes were begun with research stations at Harrow, Vineland Station, and Saskatoon and with institutes in Holland and England.

Coleoptera, Siphonaptera, and Arachnida

Handbooks. Keys, illustrations, and descriptions for 114 species of the spider families Thomisidae and Philodromidae of Canada were prepared. Work on the illustrations and distributional data for a handbook of fleas of Canada, Alaska, and Greenland continued. Work on a handbook on the beetle family Elateridae of Canada and Alaska was begun.

Arachnida. A comprehensive review of the nomenclatural and taxonomic problems of digamasellid mites was completed. A review

of the systematic relationship of the Heterocheylidae to other families was completed; a radical transfer of this group to a position next to the Tarsonemina is proposed. Some problems preventing the export of Canadian-grown apples to South Africa, because of mite pests that occur in Canada but not abroad, were investigated. A review survey of the phytophagous mite species in apple-growing regions across Canada was coordinated and begun. Research projects on the eriophyid mites associated with pomaceous and prunaceous trees, and on selected eriophyid genera associated with conifers, were initiated. Taxonomic groupings of spiders in alfalfa fields in California were studied.

Coleoptera. Considerable progress was made toward the completion of a revision of the staphylinid subfamily Tachyporinae; more than half the genera have been revised and a paper on the difficult genus *Sepedophilus* is half finished. A revision of the family Alleculidae of Chile was completed. Sixty-eight species, twenty of them new to science, in the scolytid genus *Pityophthorus* were treated, with twenty-three new synonyms discovered and all type species revised; the accumulation of distributional and biological data is continuing; the study is now about one-third complete. Substantial progress was made on a revision of the hydrophilid subfamily Sphaeridiinae with all but one large genus treated; one new tribe and two new genera were erected; several old problems in nomenclature and taxonomy of many, mostly introduced, species were clarified.

Faunistics. Spider fauna in the Mer Bleue sphagnum bog near Ottawa was investigated. About 75 species were found, though only 51 could be identified from available literature.

Collaboration with other agencies. Systematic and biological studies of parasitengone mites associated with insects in Eastern Canada by two students (J. Robillard and P. Watson) at Carleton University, Ottawa, and a taxonomic study on staphylinid tribes Gymnusini and Deinopsini by a visiting graduate student (J. Klimaszewski) from Wroclaw University, Poland, were supervised by three Institute scientists. A course on biogeography was presented at Carleton University, Ottawa, by an Institute scientist.

Diptera

Handbooks. During 1974, the majority of research time was spent on activities directly related to, or closely associated with, the preparation of a *Manual of the families and genera of North American Diptera*. Steady progress was achieved with both the text and the illustrations. Chapters on nine families were received, bringing the total number of chapters to 51 manuscripts, which is about half of the complete text. Of about 2000 required figures, 1444 illustrations have been prepared by the artist. Copies of the manuscripts and illustrations have been combined to form a working mock-up of the manual. Also, a revised key to the genera of Platypezidae and a key to the genera of Syrphidae were completed, as were substantial portions of the generic keys for the Mycetophilidae, Asilidae, Calliphoridae, Sarcophagidae, and Tachinidae. Another handbook on Diptera larvae that are found under the bark of trees was completed, and a revision of the tribes and genera of Canadian blow flies was nearly finished.

Fossils. Thirty thousand pieces of amber were collected and over 500 fossil insect specimens of numerous families were discovered. The first fossil of the biting midge genus *Leptoconops* was found in this amber, and a new fossil species of *Plecia*, which is the oldest known member of the Bibionidae, was described.

Biting flies. A new name for a subgeneric homonym in the genus *Simulium* has been proposed, and a manuscript on the black flies of Iceland was completed. The description of a new genus of black flies and a revision of the subgenera *Twinnia* and *Gymnopais* of the genus *Prosimulium* are nearing completion. Descriptions of larvae and pupae of five species of horse flies are being prepared. Rearing programs for horse flies and tree-hole species of *Culicoides* were very successful.

Parasites and predators. Analytical tables for adults and larvae have been prepared for about 250 species of flesh flies (Sarcophagidae). Good progress was made on a revision of aphid-feeding syrphids of the genera *Trichopsomyia* and *Epistrophe*. A monograph of forty species of robber flies (Asilidae) in seven genera is in press, and two papers on bat flies (Streblidae and Nycteribiidae) were completed.

Other research. Studies of lance flies (Lonchaeidae) of the world continued; catalogs of the Oriental, Ethiopian, and Neotropical species were prepared, and two papers on Oriental species were completed. Two papers are being prepared on larvae of an anthomyiid fly (Anthomyiidae) and two chloropid flies (Chloropidae) that destroy seed heads of brome grass. Description of new genera of lauxaniid flies (Lauxaniidae) based on already described species is continuing.

Experimental Taxonomy

Biosystematics of *Euxoa*. The assessment of species limits in this genus by biological and physiological studies continued to be emphasized. Much of the work centered around our laboratory-reared stocks of *Euxoa campestris* (Grote) and *E. declarata* (Walker) and their hybrids. No external features were found to distinguish the species at the larval stage, but two internal ones were highly significant: the passive form of blood cells of one class, the plasmatocytes, transformed to a simple dimension factor; and the number of neurosecretory cells in the body segments. In the hybrid larvae these internal features usually resemble those of the male parent, but are less distinctive. Eight species of *Euxoa* are now in culture in our laboratory, and hybridization and mating selection tests are being carried out to test the validity of four species from the *comosa* group, collected during the summer in southern Saskatchewan and Alberta. Detailed descriptions were made of the immature stages of *E. basalis* (Grote), which will be helpful in preparing similar descriptions of other species. A new tracheal organ from larvae in several families of Lepidoptera was described. This organ usually occurs in larvae known to be unpalatable and it seems to have the capacity to concentrate materials from the blood and to expel them at each molt.

Scattergrams based on discriminant analysis of male genetical measurements for both the laboratory-reared parent stocks of *E. campestris* and *E. declarata* deviated somewhat from those of field-collected moths, but showed the same degree of difference between the species. Scattergrams of hybrid measurements occupied an intermediate position, but were skewed toward the male parent species. Similar results were found in

electrophoretic studies, where canonical analysis of the migration distances of esterase isozymes showed the species to be far apart, whereas those of the hybrids were intermediate but usually closer to those of the male parent.

Biosystematics of Tabanidae. The esterase patterns of several populations of adults of *Atylotus thoracicus* (Hine) taken from widely separated areas showed remarkable homogeneity, typical of inbred populations. However, a single population of *Hybomitra typhus* (Whitney) occurred in two morphological forms, and one form had at least four esterase phenotypes.

Hymenoptera

Braconidae. The Haliday species of *Microctonus*, parasites of weevils, were reviewed. Two new species of *Microctonus* were described, one from South America and one from England. The European species of *Leiophron*, parasites of plant bugs, were reviewed, and 31 new Nearctic species were described. A compilation was made of all known records of incidence of parasitism by Euphorinae in the Belleville area. Six new species of *Apanteles* that parasitize microlepidopterous larvae of spruce and fir were described. An evaluation of the generic entities within the tribe Brachistini was made; a new genus was described, changes in synonymy were indicated, and all Nearctic species were assigned to correct generic position.

Ichneumonidae. An account of the entire collection of Hymenoptera in the Provancher collections at Université Laval and a detailed study of Provancher's 546 species of Ichneumonidae were completed. A compilation of parasites of forest Lepidoptera in Canada representing the subfamilies Metopiinae and Pimplinae was made.

Chalcidoidea. Cretaceous fossils from Canadian amber representing three families were studied; four new subfamilies, seven genera, and ten new species were described. Specimens representing a new species of *Ooencyrtus*, reared from the elm spanworm, were described. Cultures of *Chrysocharis laricinellae* (Ratzeburg), parasitic on the larch casebearer, were obtained from various countries and reared and crossed to determine specificity. It was found that the

specimens were all conspecific. A new Nearctic genus, *Steffanolampus* (Perilampidae), was described, and the parasites of the horn fly were reviewed.

Scelionidae. Specimens representing two sibling species of *Gryon*, egg parasites of blood-sucking Reduviidae, were described.

Lepidoptera and Trichoptera

Handbooks. Two handbooks were prepared in 1974; one is on the cutworm moths of Ontario and Quebec and the other deals with the lepidopterous leafminers of temperate North America. Both publications are in the final editorial stage.

Part III of the *Guide to the Geometridae of Canada* is in preparation. A handbook on the genera of Canadian Trichoptera was started.

Taxonomy. The genera of the *Polygrammodes* group of Pyraustinae were studied. Revision of the conifer pests of the genus *Dioryctria* was continued. A study is in progress of the larvae of 13 species of the beet webworm genus *Loxostege*.

The larvae and male genital characters for a higher classification of Microlepidoptera were investigated. The larva of the very primitive genus *Epimastyria* was discovered and is being studied and compared with other Micropterygidae.

Studies of several species groups of the cutworm genus *Euxoa*, including *punctigera* (Walker) and *mimallonis* (Grote), were completed.

About 15 taxa of Trichoptera have been described and drawn. A small collection of Trichoptera from Buthan, India, was studied.

Cultivated Crops

Oats. Research aimed at automatic identification of cultivars has reached a breakthrough with the use of inflorescence spectrography. A new classification of species of oats (wild and cultivated *Avena*) based on new data, numerical techniques, and on information theory has been completed. Our aim is to develop a system that will include various principles that may be applied in the identification of small grain cultivars with the aid of a computer.

Wild-rice. A start has been made on updating the Branch publication *Wild-rice*.

Bromegrass. Various species of bromegrass were collected in Western Canada. Revisionary studies were initiated that include compatibility trials and comparison with nomenclatural types.

Alfalfa. A biosystematic study of the genus *Medicago* (family Leguminosae) was begun. Study of species of the Section Falcago, the group of perennial species that includes the forage species, is in progress.

Cannabis. Publications summarizing previous research on *Cannabis* were completed. A paper on this subject was presented with the Cooley Award by the American Society of Plant Taxonomists. This is the first time this recognition has been awarded to a member of the Department.

Carrot. About 100 wild and 300 cultivar populations of carrot were grown outdoors to obtain materials for study. Cultivated stocks included both the familiar orange types and the purple (anthocyanin) types common in Asia from which the orange types are thought to be derived. Characteristics of the collected populations are being assessed for their taxonomic importance.

Noxious and Native Plants

Weed biology. Biological studies of three perennial hoary cresses were published. These weeds are particularly abundant in the Prairie Provinces and in the interior of British Columbia. Two of the hoary cresses were introduced into Canada about 1910 as impurities in Turkestan alfalfa. Similar studies were carried out on wild mustard, three ragweeds, and bracken. It was concluded that bracken caused red water disease in cattle and carcinogenicity in mice and rats. This information was useful to the Department of Health and Welfare when the use of

bracken crosiers as fiddleheads was suggested.

Taxonomy. Taxonomic studies were carried out on 10 species of *Draba*, 3 species of *Suaeda*, and 22 species of *Chenopodium*. Seven species of *Draba* are closely related: *D. fladnizensis* Wulfen ($n = 8$); *D. lactea* Adams ($n = 24$); *D. lonchocarpa* Rydberg ($n = 8$); *D. nivalis* Liljebl ($n = 8$); *D. palanderiana* Kjellman ($n = ?$); *D. porsildii* G. A. Mulligan ($n = 16$); and *D. subcapitata* Simmons ($n = 8$). *D. fladnizensis*, *D. lonchocarpa*, and *D. nivalis* are diploids, each with two homologous sets of eight chromosomes that are partly homologous with sets of the other two species. *D. porsildii* contains two sets of 16 chromosomes, each with two completely homologous genomes, and each genome from both sets of 16 is partly homologous with either of the genomes in the other set. All four genomes of *D. porsildii* are partly homologous with each genome of *D. fladnizensis*, *D. lonchocarpa*, and *D. nivalis*. Indument characteristics are diagnostic in taxonomic studies of *Draba* species. These and other characteristics are being utilized to develop a comprehensive key to the large *Draba* complex of Canada and Alaska. Examination of the seed coats of 22 species of goosefoot, several of which are weedy in Canada, showed distinct sculpturing patterns not previously recognized. These patterns are useful in taxonomic studies of this group.

Other activities. The problem of representing within-OTU character variability in numerical taxonomy has been considered, and the limitations of existing methods explored. A new method, the character-state frequency procedure, which can readily be incorporated into existing programs, has been developed and its operation described.

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J. W. Rouatt
Acting Director

AGRICULTURAL MICROBIOLOGY

Role of Sterols in Control and Survival of *Fusarium oxysporum*

Hydroxymethylglutaryl-CoA reductase (HMGCoA reductase), a key rate-limiting enzyme in sterol biosynthesis, has been identified in *Fusarium oxysporum* Schlecht. The enzyme is more abundant and more stable than the same enzyme in yeast or rat's liver. Several natural inhibitors of the enzyme have been isolated from the fungus as well as from other sources. These inhibitors control the rate of sterol biosynthesis.

The optimal temperature for the greatest production of both the sterol and the enzyme was 15°C using Fries medium, with cultural temperatures ranging from 10°C to 25°C. Maximum production of sterol and HMGCoA reductase occurred after 32 h in culture.

Formation of Chlamydospores in *Fusarium*

During the conversion of conidial cells to chlamydospores, new lipid bodies are formed in the cytoplasm within the membranes of the endoplasmic reticulum (ER). The first recognizable change in ER is the formation of small dilated sections. These sections subsequently increase in size and change from irregular to spherical in shape. Throughout this period the membranes surrounding the bodies are clearly defined. When the chlamydospore itself is fully developed, the membrane is not readily defined in most lipid bodies but appears as a

broad electron-dense band around the periphery.

Studies of Cell Transport in *Fusarium sulphureum*

Conidia of *Fusarium sulphureum* Schlecht. grown on potato sucrose agar accumulate leucine and glutamic acid to give a concentration gradient of 200–500 versus the external amino acid concentration. Optimum glutamate uptake occurred at pH 4.5 and 30°C, with a K_m value of 1×10^{-5} M. Optimum leucine uptake occurred at pH 7.5 and 30°C, with a K_m value of 5×10^{-6} M. Both amino acids are accumulated through permeases of broad overlapping specificities.

Lipid and Membrane Research

Lipid metabolism in *Fusarium* spp. was investigated to determine the effects of growth temperature on the composition of membrane and storage lipids of hyphal cells. Effects of temperature on both phospholipid composition and fatty acid unsaturation were striking when hyphae were grown between 15 and 37°C. At higher temperatures oleic acid was the predominant fatty acid residue, and at lower temperatures linoleic and linolenic acids were greatly elevated in all lipid classes. However, the change in the storage lipids was less pronounced than that in membrane phospholipids.

In the phospholipid components from hyphae grown at 37°C, phosphatidylcholine comprised 42% of hyphal membrane phosphorus incorporation and phosphatidylethanolamine accounted for 23%. At 15°C, the

pattern was reversed. Gross alterations in membrane properties that arise from this change are now being investigated.

Enzymes of Fungal Pathogens

Dihydro-orotate dehydrogenase was purified to homogeneity from fungi and shown to be linked to quinones, not to NAD as for some bacteria. This key enzyme of pyrimidine biosynthesis has a high molecular weight (300 000 daltons) and is a lipoprotein. The enzyme was inactivated by certain surface-active agents but activated by others. A naturally occurring lipid inhibitor is being isolated and will be characterized as a possible control agent for fungal pathogens.

Root Rot of Cereal Crops

Preconditioning of different isolates of *Helminthosporium sativum* Pamm., King & Bakke with specific amino acids altered their growth and sporulation characteristics in artificial culture and markedly reduced their pathogenicity to wheat seedlings. Amino acid conditioning also affected the sensitivity of *H. sativum* conidia to soil fungistasis. Repeated subculturing on a medium containing histidine, proline, serine, or methionine tended to increase fungistatic sensitivity; similar subculturing on a medium containing arginine rendered the isolates less sensitive to soil fungistasis than were the nonconditioned control cultures. Exudates and extracts from the roots of wheat seedlings generally counteracted the influence of soil fungistasis as indicated by a marked increase in conidial germination, but the degree of counteraction varied among the *H. sativum* cultures and appeared to depend on the specific amino acid used for preconditioning. Root exudates and extracts from a wheat variety susceptible to root rot were more effective in overcoming soil fungistasis than those from a more resistant variety.

In a pathological and biochemical study of the etiology of the root rot disease of wheat caused by *H. sativum*, 150 isolates of the causal organism were examined for toxin production in culture and phytopathogenicity in the greenhouse. None of the isolates produced any significant amount of toxin, nor were any of them particularly virulent in the greenhouse experiments.

The type of toxin produced by *H. sativum* varied with the oxygen tension of the culture

medium. When oxygen was restricted, victoxinine was produced, but when it was plentiful helminthosporal was formed.

BIOCHEMISTRY OF PLANT CELL DIFFERENTIATION

Cell Transformation

Integration of large amounts of exogenously supplied bacterial DNA into plant cells to introduce genetic modification is still controversial. A system designed to obtain unambiguous results was used to differentiate between integration of labeled DNA and reutilization of breakdown products of labeled DNA. The procedure involved the uptake of radioactive DNA by *Chlamydomonas reinhardtii* cells and the subsequent analysis of total host cell DNA by molecular sieving on Sepharose. Combined with the technique of cesium chloride density-gradient centrifugation, the DNA species, e.g., chloroplast, nuclear, and hybrid DNA, could be separated according to their various densities. The minimal uptake of exogenous DNA by these cells was about 0.02%. Even such a small amount can be very significant biologically if it is genetically stable.

Maximal degradation and minimal utilization of labeled thymidine previously found in sugar cane cells (1973 Report) was also present in cultured carrot, potato, and soybean cells. Thymidine degradation seriously limits the production of labeled plant DNA of high specific activity for use in transformation experiments. It can also lead to erroneous interpretation of radioautographic results when this commonly used precursor is employed in studies of synthesis of plant cell DNA. Of the various inhibitors tested for ability to arrest thymidine degradation, fluorodeoxyuridine, 5-fluorouracil, diazouracil, and diazouridine gave promising results over a short incubation period but were not effective on prolonged incubation because of breakdown of inhibitor.

Haploid Plants by Anther Culture

In the continuing search for a variety of *Solanum tuberosum* L. from which haploid plants can be produced, anthers of *S. stoloniferum* and *S. acaule* were tested under a variety of conditions without success. Because lack of success with *S. tuberosum* using common techniques appears to be

universal, biochemical interference with normal pollen development to force the formation of haploid plants in this species will now be tried.

Protoplasts in Plant Cells

Conditions for protoplast formation both from mesophyll cells of leaf tissue and immature pollen cells of *S. tuberosum* and from suspension-cultured cells of carrot were determined. These cells are now being used in studies of differentiation under various conditions.

ENVIRONMENTAL CHEMISTRY

Inorganic

Selenium in biological samples. A commercial, resistively heated graphite furnace was evaluated for use with atomic absorption spectrophotometry to determine nanogram quantities of selenium in biological samples. Samples were digested in acid and 5- μ l aliquots were injected into the furnace. Incorporation of Ni at 5 mg/ml substantially improved sensitivity and precision. Matrix interferences varied with the sample and method of pretreatment. For successful analyses, the element must be separated from the matrix by reduction-precipitation with ascorbic acid and redissolved in acid before determination.

Analysis of chromium. The application of flame atomic absorption spectrophotometry to the determination of chromium in biological matrices was investigated. Interference from 31 elements, normally present in a sample matrix, was evaluated by using simulated sample solutions in four commonly used digestion acids. Recovery studies in air-acetylene and nitrous oxide - acetylene flames indicated that enhancement or depression of the signal varied with the flame used, flame stoichiometry, and burner height. The nitrous oxide - acetylene flame was more effective in reducing interelement interferences and was proposed for use in chromium analyses.

Attractants for honey bee workers. Attempts were made to identify the volatile constituents of pollen, which are attractive to worker bees. An active fraction collected from pollen was observed to have the odor of orange oil. Subsequent investigation of

orange peel extracts resulted in the identification of carvone and four other compounds that are attractants.

Honey bee pheromones. The amounts of (E)-9-oxo-2-decenoic acid and (E)-9-hydroxy-2-decenoic acid present in Asian queen bees were determined in connection with the chemotaxonomy of different *Apis* species. Extracts from the Asian queens were attractive to North American worker bees.

Organic acids in tobacco. A method for determining the organic acid content of tobacco leaves was developed. Because diazomethane was found to catalyze transesterification, ethyl esters could therefore be formed as artifacts when ethereal diazomethane prepared from ethanolic KOH was used.

Pesticides. A study on the behavior of pesticides and herbicides in organic soils, done in collaboration with the Research Station, Saint-Jean, Que., and the Soil Research Institute, Ottawa, Ont., showed a marked increase in the bacterial activity of soil treated with carbofuran. This increased activity was not evident when carbofuran and linuron were applied.

In collaboration with other research stations, analytical methods for determining malathion in lettuce and apples; ethephon in apples; atrazine in water, chicken eggs, feces, and tissues; and fenitrothion in apples were developed and evaluated.

Organochlorine insecticides. Studies on the metabolism of *cis*- and *trans*-¹⁴C-chlordane in carrots and soil were completed. Both *cis*- and *trans*-chlordane were readily absorbed by carrots but were not degraded into other products. In soil, *cis*- and *trans*-¹⁴C-chlordane showed little indication of degradation.

The metabolism of *cis*- and *trans*-¹⁴C-chlordane in rabbits has also been studied. Seven metabolites isolated from the urine were identified.

Work on the metabolism of ¹⁴C-carbathiin in pheasants was completed. More than 70% of the orally administered ¹⁴C-carbathiin was excreted in the urine and feces within 7 days. Carbathiin sulfoxide, carbathiin sulfone, and hydroxycarbathiin were identified among the metabolites found in the feces and urine.

Organophosphorus insecticides. Both gas chromatography (GC) and liquid chromatography (LC) were used to determine impurities in technical-grade fenitrothion (>95%

pure). Because both bis-fenitrothion and S-methyl-bis-fenitrothion were not detected by GC, LC was the preferred method. Considerable variation was found in the fenitrothion content of nine commercial products analyzed; S-methyl-fenitrothion was the most common impurity.

Chemical derivatization was studied as a means of confirming pesticide and herbicide residues. Alkylation of organophosphorus and carbamate insecticides, triazine, and urea herbicides that have an NH moiety by sodium hydride – methyl iodide – dimethyl sulfoxide gave derivatives with GC characteristics superior to those of the parent compounds. The procedure was applied to samples of crude extracts of soil, plant, and blood and shown to be capable of confirming the identity of residues at levels of 0.02 ppm.

An analytical method sensitive to 0.02 ppm was developed for determining Mesurol (ChemAgro Corp.) in blueberries. Mesurol was separated from its sulfoxide and sulfone by silica gel chromatography and quantitated by GC. A small-scale study of blueberries treated with 143 g/ha (16 oz/ac) showed that Mesurol disappeared rapidly; less than 0.02 ppm was found after 24 days.

The isolation of ^{14}C -methyl-glutathione and de-methyl-fenitrothion after treatment of pine seeds with labeled fenitrothion indicates that a glutathione alkyltransferase system is present in the seed embryo.

Herbicides. A GC method for the determination of diquat and paraquat residues in soil was developed. Soil was extracted with 18 N H_2SO_4 , and the extract was hydrogenated in the presence of Adam's catalyst. Recoveries of the two herbicides from soils fortified at 0.1 and 0.05 ppm were between 84 and 95%. Hydrogenation of acid extracts from organic soil required more catalyst per gram of soil than did extracts from mineral soil. The pH of the soil extract did not affect the recovery of herbicide residues from field-treated samples.

The persistence and movement of paraquat in orchard soil (Fox sandy loam) were examined. Although growth of oat plants was not affected, chemical analysis indicated virtually no loss of the herbicide from soil during the summer months. The residue levels present did not appear to pose any danger to crops grown on treated soil.

Linuron undergoes rapid thermal decomposition above 170°C . The herbicide was

quantitated by GC, using a short column (38 cm) and on-column injections. Extraction studies were made with various solvent systems before the method was applied to field-treated samples.

Hydroxyatrazine, the main metabolite of atrazine in corn, is formed by a glutathione-catalyzed reaction. A method for the simultaneous determination of hydroxyatrazine and atrazine was developed and used to follow the uptake and metabolism of these compounds by chickens given atrazine-fortified feed.

Fungicides. Two transformation products of benomyl, 3-butyl-s-triazino[1,2-a]benzimidazole-2,4(1*H*,3*H*)-dione (STB) and 2-(*S*-butylureido)benzimidazole (BUB), were synthesized and derivatized by alkylation. These derivatives are readily quantified by GC. Attempts to convert benomyl to methyl-STB by treatment with sodium hydride – methyl iodide in dioxane were only partly successful (40% yield), whereas methyl-2 – benzimidazole carbamate (MBC) gave a dimethyl derivative in a 65% yield. No hydrolysis of benomyl to MBC was observed under the reaction conditions employed.

Carbathiin and its major metabolites, the sulfoxide and sulfone, are readily separated from one another and from coextractives of wheat and soil by LC. All the compounds could be analyzed in nanogram amounts with an ultraviolet detector.

WINTERHARDINESS

Environmental Factors Associated With Cold Hardiness

Cold-hardened seedlings of winter wheat were killed when totally encased in ice for 3 wk at -1°C ; when partially encased in ice, the seedlings survived even after 6 wk. Survival of plants encased in ice for 1 wk was reduced at an ice temperature of below -3°C . Alternate freezing and thawing increased the survival of plants encased in ice. Barley was the least tolerant of ice, and a hardy winter rye was more tolerant than any of the winter wheats tested. That plants partially encased in ice survive longer than plants totally encased in ice may explain the irregular winterkill of cereals in the field.

Prolonged exposure of seedlings of winter wheat to freezing temperatures well above the lethal temperature did not result in

significant damage, but injury increased markedly as the temperature approached the killing point. High levels of cold hardness were induced rapidly when seedlings of winter wheat were grown for several days at 15°C during the day and 10°C during the night, before they were exposed to hardening conditions that included diurnal freezing. Cold-acclimated winter wheat and winter barley demonstrated a capacity to rearden quickly after partial hardening.

Changes in Membrane Lipid during Hardening

The question of whether lipids of tree cells increase in unsaturation during cold hardening has been finally resolved. No significant difference in the degree of unsaturation of the fatty acids of the total lipids or the phospholipids was found between unhardy summer tree cells and extremely hardy winter cells. Development of extreme hardness in tree cells is therefore not associated with increased unsaturation of cell or membrane lipids. However, extreme hardening of tree cells is still observed to be accompanied by increased cell membrane substance as reflected in increased phospholipids. Augmentation of membranes must therefore still be viewed as a likely factor in hardening. New phospholipids for new membrane substance are apparently synthesized at the expense of the neutral lipids in the cell.

Linolenic acid biosynthesis was stimulated uniformly to produce increased unsaturation of membrane lipids in four wheat cultivars of differing hardness grown at low temperature. Increased unsaturation of membrane lipids in wheat cannot, therefore, be related directly to the hardening process, but is rather a response to low-temperature growth.

Chloroplast Membranes

Cell membranes and mitochondria in all cultivars of cold-adapted wheat seedlings have elevated levels of unsaturated fatty acids. In this condition, the cells are susceptible to peroxidation promoted by toxic products of aerobic metabolism such as superoxide anion (O_2^-) and singlet excited-state molecular oxygen. Studies showed that these species arose primarily through chloroplastic photoautoxidation when isolated chloroplasts were illuminated. Although protective enzymes are present in chloroplasts and mitochondria, O_2 is apparently formed in an

oxygen-reductant complex that is capable of causing oxidative damage. A class of reagents that selectively reacts with O_2 was developed, which could provide protection during the hardening process.

Electron spin resonance spectroscopy was used to study the effect of varying the lipid composition of wheat mitochondria and chloroplasts. Their structural properties were compared by intercalation of spin probes. When grown at 2°C, the lipid portion of mitochondrial membranes became more fluid, whereas the thylakoid membranes of chloroplasts did not. Therefore, at low temperature chloroplast membranes possessed a much more ordered bilayer structure, but showed less change in fluidity, than mitochondria did.

An unidentified soluble protein, distinguished as a new band on polyacrylamide electrophoretic gels, was detected in chloroplasts from leaves of spring and winter wheat and rye during cold hardening.

Estimation of DNA

A reliable chemical method for the determination of DNA in plants was developed and found applicable to a wide variety of tissues. The method is based on fluorimetry and is free from interference by phenolic and other compounds. Because the amount of DNA per cell is constant, estimation of DNA levels in a plant sample enables chemical changes in plant material during hardening to be expressed in terms of unit number of cells.

Isolation of Membranes from Tree Bark Cells

Membrane fractions with potassium-stimulated ATPase activity and membrane-vesicle-forming properties were isolated from hardy and nonhardy tree cells. In direct confirmation of other evidence pointing to augmentation of protoplasm and protoplasmic membranes during hardening of tree cells, more of these membrane fractions were isolated from winter-hardy tree cells than from nonhardy ones.

Mitochondrial Respiration

The effect of nucleotides and inhibitors on respiration of isolated wheat mitochondria was studied. All dinucleotides stimulated oxygen consumption and induced respiratory

control when added during state-4 respiration, subsequent to addition and exhaustion of ADP. These results and those obtained with various respiratory inhibitors suggest that dinucleotides, other than ADP, can participate in the energy conversion processes of the mitochondria, probably via transphosphorylation reactions.

Growth Regulators

The growth-promoting effect of scopoletin depends on its ability to control the catabolism of indole-3-acetic acid (IAA) in plant tissues. Inhibition of the peroxidase-catalyzed oxidation of IAA by scopoletin is caused by the preferential reactivity of peroxidase compounds I, II, and III with the coumarin derivative. By isolating and identifying the primary products of oxidation of scopoletin, we established the mechanism of the reaction and demonstrated the cooxidation of scopoletin with IAA.

Dormoats

Dark, moist storage induced a secondary dormancy in dormoat seeds. Field data from several years indicated that this treatment reduced fall germination and increased threefold the spring germination of the fall-planted seed. Seed that underwent secondary dormancy germinated less readily at low temperature than did seed with primary dormancy. Secondary dormancy was broken by mild freezing temperatures.

HOST-PARASITE RELATIONSHIPS

Clover Phyllody Agent

The leafhopper *Aphrodes bicinctus* (Schränk) was found to be an efficient vector of the clover phyllody agent (CPA). High percentages of insects, especially nymphs, can acquire CPA during relatively short access to clover. Female insects survive for several months and continue to transmit CPA somewhat erratically until shortly before death. Because *A. bicinctus* is polyphagous, it can acquire CPA from and transmit it to many cultivated and wild plant species.

Nine strawberry cultivars were tested in the greenhouse for their reaction to CPA transmitted by *A. bicinctus*, and all were found susceptible. Percentage infection ranged from a low of 5% in the Kentville selection K64-462 to 36% in the cultivar

Sparkle. Field tests suggested that the incidence of green petal disease depends not only upon the susceptibility of the cultivar to CPA but also on the attractiveness of the cultivar to the insect vector.

Mycoplasma-like organisms were purified from aster plants, *Callistephus chinensis* Nees, affected with clover phyllody disease. Sections of pellets from purified preparations showed organisms similar to those observed in earlier sections of infected plants. When healthy aster leafhoppers were injected with purified preparations and the injected insects tested in groups of 10 per plant for their ability to transmit CPA to aster seedlings, 5 out of 50 plants became infected.

Aster Yellows Disease

An isolate of celery-infecting aster yellows, maintained in the greenhouse for approximately 14 yr, underwent a change in transmissibility by the aster leafhopper. When the above isolate (O) and a similar isolate newly obtained from the field (G) were compared, isolate O was transmitted one-third to one-half less readily than isolate G when insects were given access feeds in the nymphal stage. When insects were allowed to acquire as adults, transmission of isolate O by the males was negligible, whereas females transmitted isolate O one-third to two-thirds less readily than isolate G, depending on the length of the access feed.

Wheat Striate Mosaic Virus

The minimum concentration of purified virus that could be detected serologically by precipitin ring and tube tests was $15.6 \mu\text{g/ml}$, but a viral concentration of at least $1000 \mu\text{g/ml}$ was needed to obtain a positive reaction in the agar gel double-diffusion test. The times needed to determine these titers under optimum conditions were 90 min, 18 h, and 4–5 days for ring, tube, and agar gel tests, respectively. A precipitin ring – time test was developed that could determine the amount of virus in samples of unknown concentration within a few minutes with a percentage error of only 1.65.

Barley Yellow Dwarf Virus

A bentonite flocculation technique adapted for detecting small quantities of barley yellow dwarf virus (BYDV) was not sensitive enough to detect virus in small samples from plants and aphids. The highly sensitive latex

agglutination technique was standardized for BYDV, and purified virus was detected to concentrations of $0.2 \mu\text{g/ml}$. Virus infection could also be detected with this technique in 10-g samples from oat plants but not in samples from the aphid vector.

Ryegrass Mosaic Virus

Ryegrass mosaic virus (RMV) particles and lamellar inclusions were abundant in ryegrass leaves but were localized to mesophyll and epidermal tissue. In mesophyll cells, virus occurred in membrane-bound circular sacs, embedded sometimes in callose near plasmodesmata. Cytopathological changes in the cells infected by RMV included formation of plugs or extensive cell wall deposits in and around the plasmodesmata. These plant responses apparently restrict cell-to-cell movement of virus. Abnormalities and degeneration in chloroplasts, mitochondria, and golgi were also observed. Viral protein and RNA were analyzed to characterize the virus.

AGROMETEOROLOGY RESEARCH AND SERVICE

Agroclimatic Data

Local, national, and international cooperation in programs to collect, verify, and distribute agrometeorological and biological data continued. Emphasis on international programs increased because of the critical situation in global food production and distribution. Phenological data on eight varieties of wheat grown under standardized experimental conditions and corresponding weather records were obtained for another year. This information, along with that from the other eight participating countries, will be used to develop and test crop-simulation models and to determine their application in agroclimatic surveys. There was also cooperation with the World Meteorological Organization in a second global experiment to establish standard conditions for exposing minimum thermometers near the ground. At 43 sites across Canada, agricultural research establishments continued their cooperation in collection of soil moisture data in the spring and fall.

Model Development

Ecosystem assessment. A flux meter that uses storage bins to accumulate heat, water vapor, and CO_2 was built and is being tested. In cooperation with the Engineering Research Service, a climate-controlled cabinet with six microenvironment chambers was constructed. Light intensity can be varied over a wide range. The photosynthetic capacity and transpiration rate of two varieties of spring wheat, Opal and the Mexican Siete Cerros, grown both indoors and outdoors, were measured in the chamber at several light intensities and temperatures for several stages of growth. Functional relationships between rate of growth and selected environmental factors were found for most stages and are being used to test crop-simulation models.

Management operations. A model using parameters for moisture loss and uptake by plant material and the rates of moisture movement by convection and diffusion through the swath was constructed for field drying of forages. Galerkin finite-element methods were developed to analyze this model and other similar models involving nonlinear parabolic differential equations.

Agrometeorological Analysis

Climatic resources. Photothermal resources for barley indicate that the climatically most favored 5% of our farmland is located in census divisions that contain half our urban population. This land is therefore subject to loss because of urban and other development. Climatic cooling affects crop production substantially. Estimates showed that barley that would normally mature in 94% of a 120-km^2 area near Beaverlodge, Alta., would only mature in 2% of this area if the climate were 3°C cooler.

Regional cereal yields. Research to improve the model used to predict prairie cereal yields for Canada from weather data continued. Methods were developed to map the predictions using the SYMAP computer-mapping program.

Soil moisture. The Versatile Soil Moisture Budget is fully operational and is widely used in Canada and abroad. From feedback from users and our tests against measurements, further improvements were made regarding the downward movement of internal water as a function of soil types. The computer

program was improved by adding summaries of observed and estimated values for days when observations were available and converting estimated soil moisture for zones (used in the computations) to soil moisture for depth (used in the measurements). Users can now check the estimates directly with the original soil moisture measurements obtained, for example, from the National Soil Moisture Network.

Water-deficit maps for Roseau River Valley. Weather-based irrigation scheduling was used to classify land capability. The soils of the Roseau River Valley in southeastern Manitoba and weather records at 11 climatic stations for the 8-yr period 1965–72 were selected to demonstrate the procedure. Thirty-two manuscript maps of the area were prepared and forwarded to the Lands Directorate, Department of the Environment. Averages for 8 yr showed that water deficits varied from less than 15 cm (6 in.) on the heavy soils of the area to more than 36 cm (14 in.) on the sandy soils. This study stressed that reasonable approximations of the water-holding capacities in the rooting zones of crops are necessary if soil aridity is to be assessed reliably enough for use in soil-capability studies.

Soil moisture reserves on the prairies. Data on soils, climate, crops, and cropping procedures were used to estimate water reserves in the soil under dryland conditions for 12 localities in the Prairie Provinces for each year between 1941 and 1970. Under a fallow – crop (wheat) – fallow rotation, estimates were made at various stages of crop development for soils with capacities of 18 and 29 cm (7 and 11 in.) of water in the rooting zone for planting dates of May 1 and May 20.

Agrometeorological Services

Predictions of prairie crop yield. During June and July prairie yields of wheat, oats, and barley were estimated from weather data and reported weekly to officials on the Canadian Wheat Board, in Statistics Canada, and in the Department of Industry, Trade and Commerce. Computer programs are being transferred to enable the Wheat Board to make their own predictions.

Advisory services. Through short exchange visits, advice was given to the Agronomic Institute of Campinas, Brazil, on agroclimatic

zonation mapping. Additional extension services, particularly regarding soil moisture, soil temperature, and field workday probability estimations, were provided to agricultural researchers in the Department and in other agencies and organizations.

Data-processing support. The data-processing support provided to research establishments in the Department and to other user agencies has increased significantly as a result of last year's reorganization. Data archive development has continued, and research stations at Beaverlodge, Lethbridge, and Swift Current are being assisted in establishing local data archives. Model development supporting research for winter injury, soil moisture, and workday estimations has continued. Service analyses have been processed for CANFARM, Research Branch, Economics Branch, provincial departments, and other user agencies. Program packages for the estimation of day-length, soil moisture, crop-development rate, and evaporation were distributed on request to research establishments, universities, government, and consulting agencies.

ANALYTICAL CHEMISTRY SERVICES

The Analytical Chemistry Services section, comprising five analytical units, has continued to conduct analyses for research scientists throughout the Branch.

Technological Services Unit and Microanalytical Laboratory

During the fiscal year 1973–74, 32 195 samples were analyzed, an increase of 2½% over the previous year. Approximately half of these were for Institutes and Services. Methods for determining acid detergent fiber and lignin were introduced.

Instrumentation Centre

Installation of a Finnigan GC/MS/Data Acquisition instrument has greatly increased the ability of the Centre to run mass spectra. During the two quarters April to September 1974, 833 mass spectra were produced, more than were done in the whole year prior to the acquisition of the instrument. Most of the analyses were for pesticides and their metabolites, and a data bank that now contains 260

standard spectra has been started. The DuPont mass spectrometer was adapted so that ^{15}N analyses could be carried out routinely.

Amino Acid Analysis Laboratory

Acquisition of the new Beckman 121M amino acid analyzer increased the output of the laboratory dramatically. During the year, 1684 samples were processed, more than twice the number of the previous year.

Pesticide Residue Service

During the fiscal year 1973-74, 266 samples were analyzed, which was a substantial increase over the previous year. Several organochlorine, organophosphorus, and carbamate compounds were included.

ELECTRON MICROSCOPE CENTRE

A critical-point dryer to prepare samples such as pollen grains, insect larvae, and cells in culture for scanning electron microscopy was added to the centre's facilities. This technique is generally simpler and more satisfactory than freeze-drying, although sometimes it is useful to compare results obtained by the two different methods.

Samples sent through the Postal Service for examination have included virus preparations from Harrow, Ont.; cuttings from apple trees suspected of mycoplasmal infection from Kelowna, B.C.; clover from Alberta; apple maggot, apple fruit, and leaf surfaces from Vineland, Ont.; and wheat seeds from Winnipeg, Man.

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Chemistry of sulfur compounds,
Oilseed program

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INTRODUCTION

The programs of the Food Research Institute primarily concern research for the development of optimum uses for Canadian agricultural raw materials as food. Because the Institute must continually identify those areas of research that have the highest priority, its aim is to enhance communication and collaboration with all sectors engaged in food science and technology. Such cooperation is important in planning appropriate research and development projects to meet these priorities, and to maximize the human and physical resources available for conducting these tasks. Much of our total 1974 research and development program has included both short- and long-term projects arising directly from these external interactions. The long-range research programs are continually being reassessed to ensure their pertinence to the overall objectives of Agriculture Canada.

During 1974 significant reorganization of the Institute was effected and some new administrative procedures were introduced, upon the appointment of the new Director. These changes were facilitated by excellent cooperation from the staff.

The Institute is exploring new means of informing the community of objectives and results of its work, and expects that such will be found in 1975.

During the year, Dr. Mary E. McKillican retired from the Public Service after a long and productive career in lipid chemistry research.

The Institute welcomed the arrival of Dr. Alenka Paquet and Dr. John Mullin to its staff during the year.

Reprints of the papers listed at the end of this chapter and further details about research projects are available upon request by writing to: Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

John Holme
Director

OILSEEDS

Processing Rapeseed and Mustard Seed

During 1974 the Institute was asked to produce large quantities of various rapeseed fractions for studies conducted elsewhere in Canada. These preparations were usually used in animal-feeding studies involving comparisons of nondetoxified and detoxified materials. Rapeseed fractions were detoxified by a recently modified technique, originally developed by the Institute, whereby the split seed was washed with hot water; the new process was published this year. When this process was applied to the new low-glucosinolate variety of rapeseed, Tower, meal and protein concentrates containing up to 65% protein and less than 30 ppm of glucosinolates could be prepared. As indicated in previous reports, uncertainties in analysis of the toxic compounds persist; in 1974, therefore, the Institute initiated a new project to develop improved methodology for these critical analyses.

Development of an alternate procedure for detoxification began this year. The method involves front-end dehulling and

extraction of oil from the seed before it is washed for detoxification, and definition of heat treatments required for inactivation of myrosinase. Progress to date reveals a feasible approach that is similar to the traditional soy processes of industry. Technical problems in inactivating myrosinase without insolubilizing all protein persist and are under study.

Close collaboration with the Health Protection Branch, Department of National Health and Welfare, in defining criteria for acceptability of the rapeseed fractions for human consumption has been established.

Preliminary studies indicate that the above processes are also applicable to the preparation of protein concentrates from mustard seed, and these fractions are included in various toxicity evaluations under way in collaboration with the University of Toronto and the Health Protection Branch.

Phenolic Constituents of Rapeseed

A survey of the hydrolyzable phenolic acids in *Brassica* and *Sinapis* oilseeds was submitted for publication. Study of the tannins of dehulled rapeseed and mustard

led to detection of a previously unknown polyphenol that yields pigments on treatment with alcoholic-mineral acid at room temperature and resembles anthocyanidins. This tannin is markedly different from the seed coat tannins of *B. campestris*.

Carbohydrates of Rapeseed

During 1974 this program continued with characterization of two acidic polysaccharides obtained from the oxalate-soluble acidic polysaccharide complex - pectin fraction. The acidic polysaccharide complex from rapeseed appears to be similar to that of soybean, although detailed comparisons require much more information. The rapeseed complex belongs to a group of pectinic acid type polysaccharides containing an unusually high proportion of neutral sugars.

The residue obtained after oxalate extraction of the rapeseed meal was used to prepare hemicellulose and cellulose fractions, now also under study. The fractions contained considerable amounts of protein.

Full-fat Soy Beverage Powder

In cooperation with the Canadian Hunger Foundation, a process for preparing a dried full-fat soy beverage powder was developed. Variations in the processing steps required to inactivate enzymes and antinutritive factors, to remove soy flavor, and to achieve required redispersibility of the protein, fat, and carbohydrate constituents of the soy were thoroughly evaluated and optimized to meet the requirements and facilities of the host country, Sri Lanka.

DAIRY PRODUCTS

Genetics of Starter Culture Bacteria

A comprehensive study of the genetics of starter culture bacteria (*Streptococcus lactis* and *S. cremoris*) is under way. The search for suitable marker genes revealed a close relationship between sensitivity to some antibiotics and susceptibility to certain bacteriophages. The relationships with other economically important characteristics are under study. Electron microscopy studies revealed that extrachromosomal DNA exists in the form of four distinctly different ring-shaped plasmids. The genes for drug resistance and phage resistance may be on the same plasmid, thus accounting for the close linkage.

Some of the drug- and phage-resistant mutants remained stable for a year.

Milk Quality

Psychotropic organisms, which are mostly gram-negative, nonsporing rods, grow profusely in many commercial milk supplies. Some of these organisms produce heat-stable proteolytic enzymes that can continue to degrade protein both during processing and in the finished product. Studies showed that proteolysis occurred when selected organisms were grown in milk. This process could be significant in decreasing the yield and possibly the quality of cheese because the hydrolyzed proteins remain soluble and are lost in the whey. Studies will continue on commercial milk supplies in 1975.

Quality Criteria for Canadian Cheddar Cheese

An extensive study of the chemical, physical, microbiological, and flavor characteristics of many commercially prepared samples of Cheddar cheese was completed. The data are being analyzed in order to define criteria for evaluating this cheese objectively and for describing its uniqueness and suitability as a specialty cheese.

Flavor of Cheddar Cheese

A study of the origin of the fruity flavor defect in Cheddar cheese was completed. The defect is clearly produced by high levels of ethyl butyrate and hexanoate, accompanied by ethyl alcohol. When cultured in skim milk with added ethanol, organisms isolated from fruity cheese produced high levels of these esters. A paper relating the study to the commercial significance of this defect has been published.

Pyrazines, important flavor constituents in foods, were detected in Cheddar cheese volatiles. Characterization of these compounds is under way, and their relationship to the nutty flavor of Cheddar is being investigated.

During 1974 initial studies on whey flavor were begun to assess the extent to which the Institute will enter this area of research in 1975.

Rennet Replacements

In collaboration with industry, the University of Guelph, and regulatory agencies, several enzyme systems were evaluated for

efficacy as replacements for rennet. Bovine pepsin was thoroughly evaluated, and studies will continue on the defects shown by this enzyme in yield. An enzyme system from *Mucor miehei* was recommended for approval as a rennet replacement, and approval for a previously recommended product from *Mucor pusillus* was obtained.

Gelation of Milk Products

Several previously studied aspects of heat-induced gelation of milk proteins were published. During 1974 electron microscopy was again used to try to detect sulfur in gelled proteins, but the results are still unreliable. Possible interferences with the derivatization of the SH groups are being studied.

The development of the structure of Cheddar cheese through transitions of the casein micelles is being characterized by electron microscopy. The particular stage at which the individual identity of the casein micelles is lost is being detailed, and the relationship of the appearance of the mass to other rheological characteristics will be established. The spatial distribution of micelles in longitudinal and transverse sections of the laminar structure of pile curd has been described.

In collaboration with The Netherlands Institute for Dairy Research (NIZO), the mechanism of age-thickening of milk treated at ultra-high temperatures was studied. Data pertaining to the hypothesis that degradation products arising from residual proteolytic action were the principal cause of the gelling did not support this theory. The alterations that arise in many physical characteristics of the heated milk were described, and several factors previously believed to be important causes of gelling were shown to be noncritical. Oxidation-reduction reactions have been implicated and will form the main basis for further studies.

An additional project conducted at NIZO concerned the development of tests for stability of milk during heat treatment. The results revealed that pH, agitation, and charge of the casein micelles were not dominant factors affecting the coagulation of the milk. Electron microscopy revealed that the casein micelles in these gelled products are physically attached to form aggregates and are not linked by filamentous components seen in other dairy products.

Whey Utilization

In cooperation with the Dairy Division of Agriculture Canada, a symposium on whey utilization was organized and conducted. All aspects of the subject were presented by a variety of invited speakers, and the Proceedings were prepared.

Experimental work on the thermal coagulation of whey proteins under acidic conditions has produced whey protein concentrates that possess higher solubility, greater water-binding capacity, lighter color, and increased ability to form smooth-textured gels upon reconstitution than do available commercial products. Pilot plant facilities for preparing these products were introduced at the Institute and are being employed to assess the technical and economic feasibility of these processes.

MEATS

In response to increased priority given by the Department to meat research, the program of the Institute was strengthened and several new projects were introduced.

Role of Constituents in Comminuted Meats

Formulations and processing conditions for wiener preparation in the laboratory and the pilot plant were chosen, and data on the role of meat constituents in comminuted meat products were collected. Products containing various levels of several meat constituents were produced to show the effects of substituting protein and fat upon yield, stability, texture, and sensory characteristics of the wieners. Meat protein constituents were pretreated by heating or drying to reveal the effect upon wieners of modifying the physical characteristics of the meat protein. Such studies are leading to more detailed examination of protein fractions isolated from the meat muscle constituents and of the effects of various treatments on the ability of these proteins to produce emulsification and water binding in comminuted meats. By altering the kinds of fat in wieners, the importance of the physical characteristics of the fat in forming the meat emulsion and in maintaining its stability during processing was demonstrated.

The effects on emulsion formation and stability produced by substituting various plant proteins for meat in wieners are also

being determined. Attempts to relate these effects to the physical properties of the various plant proteins are being made. The importance of solubility and prior heat treatment has been recognized. Reproducible techniques for emulsion and wiener preparation were developed, which allowed a correlation between objective textured assessment and sensory evaluation to be established.

A survey of research done on the use of nitrosamine in curing meat was completed, and recommendations were made for specific research projects in this area. Development of a method for analysis of nitrite at levels to 1 ppm was initiated, a procedure that will be important when studying the fate of nitrite in curing and assessing potential nitrite replacements.

Amino Acid Analysis

The procedure referred to in previous reports for analysis of methylated amino acids in meat protein hydrolysates was completed and published. During 1974 additional studies to simplify and shorten the procedure were undertaken. The method has been applied to several nonmeat protein sources, wiener emulsions, and wieners, and the data are being tabulated to determine whether the method is capable of analyzing for meat in mixtures of meat and plant protein.

Effects of Rigor Mortis on Beef Muscle

The tedious task of isolating pure proteins from meat muscle obtained at various stages of rigor continues. Characterization of these species, including determination of myosin-to-actin ratios and contents of methylated amino acids in each, is under way. An initial study of the denaturation of actin was completed in collaboration with Dr. C. C. Bigelow of Memorial University.

CEREALS AND FIELD CROPS

Oats

A significant expansion of the research on high-protein oats was undertaken in 1974, based on several interesting characteristics revealed in preliminary studies and mentioned in the previous Annual Report of the Institute. The correlation between high-protein content and absence of β -1,3-glucanase activity in high-protein varieties is not

being borne out. Other agronomic factors, such as location of growth, appear to inhibit the inherent enzyme activity. This inhibition may be the factor allowing the extraction of highly viscose gums.

Differences in the starch fraction of high-protein varieties from those in normal varieties and in other cereals have prompted extensive studies to characterize the starch and determine its potential in several food and nonfood uses. Data indicate that the starch of high-protein oats behaves more like high amylopectin starch and produces gels of greater clarity, diminished brittleness, and improved freeze-thaw stability than the normal cereal starches do.

Both wet and dry methods of fractionating oats have been attempted. No significant shifts of protein content between fractions have as yet been observed. Wet milling procedures appear inferior because the high viscosity of slurries caused by gums renders centrifugation difficult, and the high volumes of water required lessen economic feasibility. Procedures to overcome these problems are now being studied.

Wet fractionation procedures in the laboratory have provided protein and starch fractions that retain considerable quantities of lipid (20% and up to 2%, respectively). Studies to characterize the fractions indicate that their physical properties are being affected significantly by these lipids. A new project was initiated in 1974 to characterize oat lipids and to determine the nature and extent of their interaction with proteins and starch. Comparative data on lipid composition of normal and high-protein oat varieties are being collected.

The variable, but interesting, occurrence of high-viscosity gums in oats also led to the initiation of research to characterize them and to determine the enzymic reactions that control the physical properties of these materials. Comparisons of chemical composition of these gums with the glucans of barley are being developed.

A significant project in the cereals program concerns a study of the extrusion cooking of cereals and their components. An extensively modified Brabender extruder was employed to develop a quantitative picture of the gelatinization of cornstarch under various operating parameters of extrusion. The characteristics of various "states of gelatinization" are also being employed to compare the effects of extrusion conditions on various

starches, and to identify the effects of other constituents (lipids, salts, protein, other additives) on the gelatinization of starch in cereal-based food products normally prepared by such processes.

Durum Wheat

Plans for an international study of the quality characteristics of durum wheats were finalized, and the kinds of data expected are being analyzed by statistical methods to develop a treatment for the results that will be obtained in 1976-77.

The study of the characteristics of durum wheat that account for good spaghetti quality has led to a detailed examination of the gluten protein mass and its constituents. The proteins and glutenin subunits from a variety of durum wheat varieties were fractionated and characterized by gel filtration and electrophoresis. The results will be correlated with spaghetti quality using objective and sensory evaluation procedures performed at the Grain Research Laboratory in Winnipeg and at the Institute.

The effects produced by processing durum wheat semolina to pasta and cooking the pasta for consumption on the properties of the gluten proteins are also under investigation. The rather mild time-temperature conditions of pasta drying do not appear to alter markedly the gluten solubilities or molecular weight distributions. The cooking of pasta, which requires heating for up to 15 min at 98°C, does cause marked reduction of the solubility of gluten proteins in various solvents. The changes in protein properties

produced by such heat treatments are under study.

Buckwheat

A broad study of several characteristics of this crop was completed and will be published in 1975. Previously reported dry milling procedures that produced a fraction containing 40% protein were compared with air classification techniques that do not produce significant protein shifts. Wet fractionation procedures were also employed to yield protein concentrates, protein isolates, and starch fractions. The emulsification and water-binding properties of these fractions, as determined by various functionality tests, and their behavior in actual prototype foods such as soba, bread, biscuits, and wieners were compared with other protein sources. Buckwheat protein was observed to behave well in comminuted meat emulsions. The starch of buckwheat appears to be resistant to chemical gelatinization when compared with starches of cereal origin.

Field Beans

A collaborative study concerning off-flavor development in beans during storage and distribution was undertaken this year. The role of the Food Research Institute is to define the effects of storage conditions on mold growth and off-flavor appearance, to identify the molds that grow under these conditions, and to determine the conditions of storage required to prevent such changes. Sensory evaluation techniques will be utilized for flavor recognition.

PUBLICATIONS

Research

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INTRODUCTION

The main purpose of the Soil Research Institute is to develop and interpret an inventory of the soil resources of Canada. This task requires soil survey to obtain the basic inventory information; in-depth research into various aspects of soils to improve understanding of soil properties and behavior; interpretive research to apply the basic knowledge of soils to the solution of problems in use and management of the soil resource; development and application of a computer-based soil information system; and cartography to display soil resource information in map form. Progress was made in 1974 in all aspects of this continuing program.

The Soil Survey Units in all provinces have responded to growing demands for soil information by carrying out a number of special projects in addition to the regular survey programs. Research on the interpretation of soil resource information was intensified. The characterization and classification of soils of northern Canada were improved. Progress was made in defining interactions among heavy metals, soils, and plants, and clarifying the nature of soil humus and the weathering processes of clay minerals. Digitizing of basic soil maps made the production of interpretive maps much more efficient.

Reprints of publications listed are available from the authors. Correspondence should be addressed to: Soil Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. A. McKeague
Acting Director

SOIL RESOURCE INVENTORY

The Soil Resource Inventory Program includes personnel of the soil survey units throughout Canada and a group at headquarters of the Soil Research Institute (SRI) in Ottawa concerned with correlation, research, and related functions. Soil survey units in all provinces were united in 1974 through administration by the SRI, Ottawa. This arrangement should improve coordination of the work and increase flexibility. As examples of such flexibility, in 1974 Dr. J. I. Sneddon, British Columbia Unit of SRI, was seconded to the Department of Indian and Northern Affairs to work on land settlement policy in the Yukon and Northwest Territories, and Dr. L. S. Crosson, Saskatchewan Unit of SRI, was seconded to the Canada Center for Remote Sensing to work for 3 months on crop identification from satellite imagery.

Demands for soil survey information and its interpretation for many purposes were heavy throughout Canada in 1974. Most of the provinces hired additional pedologists to work cooperatively with the federal staff on projects of high priority. This placed increasing demands on the federal units to fulfil correlation and research roles in addition to continuing the basic inventory work. For

example, in British Columbia where the provincial soil survey staff numbers about 20, two of the senior federal pedologists were assigned to correlation as a major function in order to improve consistency of soil mapping and classification throughout the province. Interpretive research is essential if soil survey information is to be applied effectively to land-use planning and management, and federal personnel are becoming increasingly involved in this role.

Pilot studies on land evaluation for agriculture started in Saskatchewan in 1974. The basic idea of land evaluation is to assemble, synthesize, and interpret information from several disciplines pertaining to land. This makes it possible to assess the productive potential of the land under given management practices and to predict the probable economic returns from it. The process also provides a system for evaluating land use alternatives in economic terms. Pedologists, agronomists, climatologists, and economists cooperate in the project, and the soil data bank, CanSIS, is an essential tool. Expansion of this work is anticipated in the years ahead as demands on good land intensify.

Progress was made in several aspects of interpretation of soil resource information. Reports on potential agricultural productivity of soils of the Atlantic Provinces, Ontario,

and Quebec were completed and small-scale (1:1,000,000) agricultural capability maps of Alberta, Saskatchewan, and Ontario were prepared. Engineering, recreation, and forestry interpretations were improved through cooperative work with specialists in these fields.

Quality control of soil survey was improved through further emphasis on correlation, the development of a system of landform classification, and improvements in the standardization of soil analysis. The requirements of CanSIS necessitate an increased degree of uniformity of data collection and coding throughout the country. A national meeting of the Canada Soil Survey Committee in Ottawa, and workshops on organic soils in Winnipeg and on landforms in British Columbia and Alberta, contributed toward unification of concepts and operations.

The soil data and description files of CanSIS were revised completely and the digitizing of soil maps began. This process facilitates the production of interpretive maps. About 1,600 descriptions of soils and sites were coded by the soil survey units and about 1,200 of these were put into the system. Parks Canada and the Government of Manitoba are planning to contribute resources and to use CanSIS as a management system for natural resource data from areas being surveyed under their auspices.

Research continued on the usefulness of remotely sensed imagery for identifying terrain features and land use. In the cooperative U.S. - Canadian spring wheat project, ground truth data were obtained from 16 test areas for which multiband aerial photography and ERTS-1 imagery were available. Accuracy of identification of crops from the imagery depended upon several factors, including the stage of maturity of the crop, but it was high under favorable conditions. Other tests of crop identification from ERTS imagery were made in Kent County, Ont., where fields of corn, wheat, and soybeans were identified. The best date for identifying these crops depended upon the soil on which the crops were grown. In southern Alberta, fields of winter wheat were identified on ERTS imagery in late June and early July with 100% accuracy. Summerfallow fields in the area were readily identified unless they were covered with straw, weeds, or volunteer grain crops.

In soil genesis and classification, a new order, Cryosolic soils, was established to set

apart soils that have permafrost within 1 m of the surface. Various kinds of Cryosolic soils were characterized in detail and concepts of their genesis were developed. Field and laboratory studies in Winnipeg and Ottawa on the soil water regime produced improved methods of measuring soil hydraulic conductivity and a clearer understanding of relationships among water table level, soil properties, and redox potential. Information on the distribution of volcanic ash in British Columbia was summarized and its effect on soil properties at three sites was determined. Fragipans of several soils in Nova Scotia were characterized and evidence from scanning electron microscopy suggested that clay bridges between sand and silt grains might be responsible for their coherence. An interstratified kaolinite-montmorillonite was identified in a soil from the Yukon.

Soil Survey

The Canada Soil Survey is a cooperative program involving federal and provincial agencies. During 1974, about 8.1 million ha were surveyed at the reconnaissance level, 67 000 ha at the detailed level, 23.8 million ha at the exploratory level, and 11.1 million ha for agricultural capability (see Table). Soil survey activities by province are summarized below.

Newfoundland. Soil mapping at a scale of 1:250,000 was nearly completed in the areas of Port aux Basques and Stephenville, was in progress in the Codroy Valley and Cormack areas, and started for the Botwood map sheet.

Prince Edward Island. In the detailed resurvey of Prince Edward Island 77 000 ha were mapped in 1974. Progress was made in rating the suitabilities of soils for various crops and a study of soil erosion continued.

Nova Scotia. The survey of Colchester County continued and the mapping legend was revised. Studies started on ortstein and turbated soils.

New Brunswick. Surveys proceeded in the areas of Richibucto-Rogersville, St. John River Islands, and Maugerville-Sheffield. The field mapping of the Minto-Chipman-Harcourt area was checked and a draft of the Madawaska report was completed. Soil survey data were interpreted for agriculture, forestry, and overall planning purposes.

AREA SURVEYED IN 1974 AND TOTAL AREA SURVEYED

Survey type	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.	NWT & YT	Total
Soil surveys — thousands of hectares												
New surveys*												
Reconn.	1974	5,840	—	121	—	78	152	—	—	—	—	6,191
Total	47,974	19,069	28,252	18,975	15,156	7,404	4,594	5,300	595	1,266	3,708	152,293
Detailed	1974	67	—	—	—	—	—	—	—	—	—	67
Total	108	52	—	—	—	—	—	—	—	—	17	177
Exploratory	1974	—	—	2,308	—	14,575	—	—	—	405	6,478	23,766
Total	2,631	42,429	10,931	6,045	5,686	22,267	—	—	—	1,649	31,417	123,055
Resurveys*												
Reconn.	1974	733	491	405	—	—	—	54	—	—	—	1,683
Total	4,536	15,551	19,133	46	476	334	28	527	—	—	—	40,631
Detailed	1974	—	122	—	227	101	—	—	77	—	—	527
Total	366	1,635	2,079	1,040	621	—	—	23	482	—	—	6,246
Canada Land Inventory — thousands of hectares												
Agriculture												
New	1974	6,690	2,024	—	—	—	—	—	—	945	—	9,659
Total	44,504	45,344	36,003	19,348	20,914	30,249	7,119	5,300	566	2,927	3,530	215,804
Reassessed	1974	773	—	529	—	—	152	—	—	—	—	1,454
Total	4,012	—	1,757	756	332	—	152	—	—	—	—	7,009

* Reconnaissance at scale 1:50,000 to 1:126,720; detailed at scale of less than 1:50,000; and exploratory at scale greater than 1:125,000.

Quebec. Field work was completed by the provincial group in Dorchester County, Ile d'Orléans, and Ile-aux-Coudres, and continued in Témiscouata, Charlevoix, and the area comprising Arthabaska, Wolfe, Frontenac, Mégantic, and Beauce. In the exploratory biophysical survey of the James Bay region by the Canadian Forestry Service, 14.6 million ha were mapped.

Ontario. Soil surveys were conducted mainly in the southern counties, because intensive land-use pressures exist in this area and existing information on soils is inadequate for making decisions on present or future land use. Soil surveys were in progress in Middlesex County and the regional municipalities of Haldimand-Norfolk and Ottawa-Carleton. A detailed scale was selected because this will provide the information on physical resources required for making decisions on agricultural, urban, and recreational uses of lands, and for choosing land for waste disposal. Ad hoc soil surveys were conducted along part of the Lake Temagami shoreline in northeastern Ontario to determine the suitability of the area for further recreational development, and to assess the impact of development on environmental conditions of the region. A detailed soil survey was conducted on the Holland Marsh in southwestern Ontario to provide information for development of a more equitable system of taxation based on the productive potential of the soil. The latter two projects were funded by sources other than Agriculture Canada.

Research conducted by personnel of the survey unit provides the data needed to improve the interpretability of soil survey information, and to assess the effects of soil and landscape characteristics and agricultural land-use practices on environmental quality.

A study was in progress to establish indices for rating soil series according to their productive capacity for forestry. Plantations of red pine in southern Ontario were first chosen for the study, in which growth data from trees 25 to 40 yr of age were related to the physical, chemical, and morphological properties of soils. Productivity indices of these soils ranged from a low value of 40 to a high of 80 on a 100-point scale. During 1974 the study was extended to include soils of eastern and northern Ontario. Further research associated with this project indicated

that widespread mortality of red pine more than 25 to 30 yr old was occurring on Melanic Brunisol soils because of excessive accumulation of Ca and Mg in the surface horizons.

Soil erosion studies began on areas in several physiographic regions under various land-use practices in southern Ontario. The Universal Soil Loss Equation was used for Ontario climatic conditions to compute potential losses from agricultural land caused by sheet erosion. Initial computations indicated that annual losses by sheet erosion ranged from 0 to 20 t/ha in southern Ontario. The magnitude of stream bank erosion was also under study to clarify the origin of sediments in stream water. Equilibria between stream water, suspended sediments, and bottom sediments were examined to evaluate the effect of sediments on stream water quality.

Manitoba. Results of the study of soils of the Morden-Winkler area were published. Reports and maps were in press for the study on Organic soils in the map areas of the Roseau River Basin, Red Rose - Washow Bay, and Ste. Rose du Lac. Reports and maps were in preparation for the areas of Virden, Winnipeg Region, and Waterhen, and preliminary or interim reports and maps for areas of Cormorant Lake, Wekusko, Norway House, and Cross Lake. Surveys of Grand Rapids, The Pas, Swan Lake, and Pointe du Bois are at various stages of completion.

A biophysical survey started in northern Manitoba; this project will include all areas of the province not covered by standard reconnaissance survey. Approximately 2.3 million ha were surveyed in 1974.

Research in support of inventories included evaluation of remote sensing techniques, chemistry and morphology of imperfectly and poorly drained soils, characterization of Cryosolic soils and Organic soils, and development of a biophysical system of land classification for Manitoba.

Saskatchewan. Correlation of soil mapping and sample collection were completed in the Swift Current map area and maps were being compiled. Several new soil associations were established during the survey and soils apparently developed in loessial sediments were distinguished from those on lacustrine deposits. Results from a 3-yr study of wheat

and forage productivity on one of the dominant soils were summarized for inclusion in the final report.

At the request of the Parks Branch, work began on a biophysical land classification of Prince Albert National Park. It will provide information on surficial deposits, soils, landforms, and vegetation, so that these resources can be used and managed properly as a park. Areas delineated by photo interpretation were checked by traverses on foot to provide ground truth. Six sites were established to monitor air and soil temperatures, precipitation, and soil water.

Research continued on the evaluation of salt contamination in areas around potash mines and on naturally occurring salinity. Contamination from salt dust is minimal except very close to the source. Fluctuations of soil salinity occur naturally in the agricultural area as a result of short-term climatic changes. Groundwater quality and levels are being monitored in saline areas.

A program to evaluate the relationship of site quality to the nutrient content in foliage of jack pine, black spruce, white spruce, and trembling aspen continued in cooperation with the Forestry Branch. The softwood species were shown to be deficient in N and P, and on the borderline of deficiency in K, Ca, and Mg. Variations in yield from sites that differed in quality could be attributed, in part, to differences in clay content and availability of nutrients.

Eight sites were mapped and sampled in detail to determine the relationship among position in the landscape, soil morphology, and soil chemical and physical properties. Such information is required for accurate soil mapping and for land appraisal and assessment.

H. B. Stonehouse carried out a soil survey in Tanzania as part of a CIDA project.

Alberta. The Alberta survey program, which integrates federal and provincial personnel, ranged from reconnaissance surveys in areas of limited access south of the Peace River country to very detailed surveys for urban and parks planning, mainly in the Calgary region. National Parks surveys continued; those of Yoho, B.C., and Elk Island were nearly completed and a 5-yr program with Canadian Forestry Service started in Banff and Jasper Parks. Research included a pilot survey of a county at a scale of 1:30,000, remote sensing, crop yield in

relation to Canada Land Inventory capability classes, and development of improved methods of map and report presentation. T. W. Peters spent 2 months with a CIDA project in Indonesia and W. W. Pettapiece was on a transfer of work to the SRI, Ottawa until July.

British Columbia. Soil surveys continued in the following areas: Ominica-Parsnip, Peace River, south Vancouver Island and Gulf Islands, Manson River, East Kootenay, Ashcroft, Kluskus, Queen Charlotte Islands, and Stikine. Ratings of agricultural and forestry capability were revised for some 2.8 million ha in the Fort George area and 2.2 million ha in the Cariboo area.

An integrated program of soil correlation was in progress; it involves SRI, the British Columbia Department of Agriculture (BCDA), and the Resource and Analysis Unit of the British Columbia Environmental and Land Use Committee secretariat (ELUC). A general soil map of British Columbia at a scale of 1:1,000,000 was in preparation.

Research was carried out on interpretations of soils information for various purposes. The pedology unit was involved in a joint project with the Pulp and Paper Research Institute, ELUC, BCDA, and three private forest companies to assess the effects of highlead logging on soil properties and soil erosion. A study of the impact of forest management practices on Lithic soils in the Nimpkish area of northern Vancouver Island was completed. Contributions were made to field studies and committee work on engineering aspects of soils, land planning, and waste water treatment in several areas. One such project, a biophysical evaluation of a rural subdivision in the Peace River, originated through the ELUC secretariat. A map and report of the 265 ha surveyed were used by planners to formulate guidelines for land use. A cooperative study with ELUC was undertaken to evaluate slumping hazard and its effect on the recreation potential of the Williams Lake Reservoir.

A project was undertaken at the request of the Analyses Unit of the secretariat to suggest suitable remote sensing techniques for the acquisition of natural resource data in northern British Columbia at a scale of 1:1,000,000; the project also included tests of personal visual abilities in mapping accuracy for staff members of ELUC. All members of

the Vancouver Pedology Unit were tested for acuity, stereopsis, phorias, and color vision. The accuracy of mapping by individuals on four different types of photography was measured and appreciable individual differences were noted.

Yukon and Northwest Territories. An extensive biophysical survey of approximately 6.5 million ha in the Boothia Peninsula region of the Northwest Territories was completed in cooperation with the Geological Survey of Canada. Ground truth was obtained on landforms, ground ice, soils, and vegetation, and significant climatic regions or ecoregions were identified. Pedological studies and tests were conducted on the suitability of the tentative classification of Cryosolic soils.

Assessments were made of the agricultural capabilities of soils in the Mills Lake and Whitehorse areas, for the Department of Indian and Northern Affairs.

Cartography. The Section completed drafting nine soil and miscellaneous maps for federal and provincial soil surveys. These were published together with 11 maps held over from 1973, for a total of 20. Approximately 40 other soil and resource maps were at various production stages at the end of 1974. A simultaneous process of scribing and digitizing soil lines and symbols for CanSIS and map publication was introduced late in the year and will become the standard production method in 1975.

There were 173 capability maps published for the Canada Land Inventory, Department of the Environment; 212 were cartographically complete but awaited translation of area descriptions, and 300 capability maps were at various production stages.

Reproduction services were also provided on request to other institutes, agencies, and branches within the Department on a cost recovery basis. Some work was done for other departments under reciprocal agreements.

Great Lakes Watershed Study

As part of Agriculture Canada's contribution to implementation of the Great Lakes Water Quality Programme, the Soil Research Institute (SRI) and Engineering Research Service (ERS) helped to develop and implement the study for the agricultural portion of the Task C study, International Reference Group on Great Lakes Pollution from Land

Use Activities (PLUARG). The objective was to obtain data on the inputs of pollutants into the Great Lakes drainage system from agricultural activities. The approach taken was to identify 'agricultural regions' within which representative watersheds could be selected for study. Agricultural regions were defined as regions of similar soils, in the same climatic zone, and with an identifiable agricultural land use or combination of land uses.

To identify these regions the following projects were carried out by SRI and ERS: classification of soils according to potential for pollutant transfer and preparation of maps; a land use inventory consisting of a cartographic presentation of data from the 1971 Census of Agriculture by a computer mapping technique (SYMAP); a livestock operations inventory and investigation to identify the major sources of livestock wastes in southern Ontario and to estimate their potential for contamination of rivers and lakes; identification of agricultural regions and selection of possible representative watersheds; and preparation of land-use maps for the watersheds selected by the Agricultural Sub-Committee, Task C, PLUARG. A joint SRI-ERS report on these activities was prepared.

ORGANIC SOILS

A new program was set up to improve the conservation and use of the organic soil resources of Canada, especially in areas near centers of population. Organic soils occupy an estimated 10% of the land area of Canada and their potential has not been developed. Early research focused on improving knowledge of the causes and control of subsidence of Organic soils, characterizing their properties in relation to botanical composition, and investigating the interactions of microbes and pesticides in them. The program involves cooperation with the Research Station at Saint-Jean, Qué.

Three extensive peat deposits in southern Quebec were partly surveyed and classified as dominantly Terric and Limno subgroups of Mesisols. The phenolic content of pyrophosphate extracts of Organic soils was studied.

The inordinate persistence of even biodegradable pesticides in soil, and the influence of humus content on the extent of their retention, suggest that a portion of certain

pesticides added to soil is incorporated into soil humus. An examination of this possibility through chemical methods of degrading natural humic materials from treated soils is difficult because of the nature of soil humus. The approach evolved for this program showed that methoxychlor was incorporated into a model 'humic' material synthesized by the fungus *Aspergillus versicolor* through forces stronger than those of physical adsorption. This humic material was depolymerized through degradation by the fairy ring fungus, *Marasmius oreades*, which resulted in release of the methoxychlor; this demonstrated an actual case of incorporation. Such incorporation was also indicated when ^{14}C -methoxychlor was apparently held in a polymer synthesized from hydroquinone. The biodegradation approach is now being used in situ in organic and mineral soils amended with labeled and unlabeled pesticides. Microorganisms capable of utilizing humic materials may thus be useful in determining the nature of pesticide retention by soil humus.

WATER AND NUTRIENT TRANSPORT

The purpose of the water and nutrient transport program is to develop models of the soil-solution system that can be used to predict quantities and rates of movement of plant nutrients and water in soil. The research, which involves in-depth work in soil physics and applied mathematics, has application to practical matters such as the addition of fertilizers and wastes to soil to enhance crop production without polluting surface and ground water.

The development or testing of methods to measure soil hydrologic properties continued. The air-entry permeameter for measuring hydraulic conductivity was modified and found satisfactory for a number of field soils. A modification of Penman's equation for predicting potential evaporation was published; it provided the upper boundary condition for computing evaporation from soil. The equation was combined with Richards' equation for water movement through soil so that evaporation losses could be computed when either meteorological or soil conditions were limiting factors. The method should provide estimates of moisture changes at different depths in the soil profile

for a range of weather, soil, and tillage conditions. Field tests of the procedures started.

Research was undertaken on the nitrogen cycle under the climatic conditions of Eastern Canada, and on the transport of nitrate, ammonium, and chloride under saturated conditions. A simple model of nitrogen and water transport in soil was developed, and testing of the model began.

NUTRIENT AND WASTE MANAGEMENT

The purpose of the nutrient and waste management program is to carry out research that will lead to more effective use and management of fertilizers, manures, and wastes, so as to avoid pollution of the environment resulting from agricultural practices and the disposal of wastes on soil.

In a laboratory study of nitrogen transformations in a soil in which the clay was largely vermiculite, about 40% of the ammonium added in liquid manure or as ammonium sulfate was fixed on the clay minerals. A part of this fixed ammonium was nitrified after the exchangeable ammonium but in general it acted as a 'slow-release' nitrogen fertilizer, resistant to nitrification and leaching.

Nutrient levels in groundwater and tile drain effluent from a farm where moderately high levels of fertilizers and liquid manure were used were not excessively high except in water from depths of 4.5 and 6 m in a sandy manure disposal area where nitrogen had been added at 1340 kg/ha annually. In this case nitrate nitrogen was found in the water at concentrations up to 88 μg ml.

The amounts of Zn extracted from several amended soils with 0.005 M DTPA, 1 M MgCl_2 , and 0.01 M CaCl_2 were highly correlated with the concentrations of Zn in the plants. Addition of phosphate to the soils tended to decrease the amounts of Zn in corn and lettuce but almost invariably increased the extractability of Zn from the soils. The concentrations of Hg in several plant species tended to be lower in the edible portion (fruit, grain, or roots) than in the remainder of the plants. The retention of Hg in soils against volatilization was increased markedly by the presence of organic matter and by addition of flowers of sulfur. Related studies were carried out on extractable metals and

their uptake by plants in acid mine tailings with various amendments.

Studies on the degradation of sewage sludge in soils and the extractability of sludge metals from soils are being funded under provisions of the Canada-Ontario Agreement on Great Lakes Water Quality. Anaerobically digested sewage sludges contain some easily degradable organic constituents. Approximately one-fifth of the carbon from each sludge tested evolved to carbon dioxide within 25 days when four sludges were incubated with soil. All sludges increased the amounts of extractable metals in soils; hence, use of sludge in agriculture involves a risk of metal pollution of soils.

A study of the reactions of phosphate in clay systems approximating acid soils showed that an interlayer hydroxy aluminum phosphate, with a chemical composition similar to that of variscite, formed in acid montmorillonite. Heating to 50°C made the interlayer material disappear and variscite form as a discrete phase.

ACTIVE FRACTION AND SOIL BEHAVIOR

The purpose of the program on the active fraction and soil behavior is to determine the nature and transformations of the active fraction (clay and organic matter) of soils and its influence on soil behavior and response to management. The active fraction has a major influence on the physical conditions and strength of soils and their capacity to hold water and retain nutrients.

A rather simple 'intensity-factor' method was developed for making quantitative estimates of the amounts of clay minerals in soils, and the method was applied successfully to the analysis of some soil clays. Laboratory weathering experiments produced the following findings. A partial structural disturbance by oxidation of ferrous iron or by dehydration (structural water) was essential for the transformation of chlorite into vermiculite. Particle size was one important factor influencing the type of layer sequence in an interstratified structure during the alteration of mica to vermiculite. Selectivity of K over Ca in weathering micas was influenced more by inclination of OH dipoles

than by tetrahedral or octahedral location of charge; in contrast, interlayer hydration was influenced more by charge location, being greater in the case of octahedral charge location. The presence of small amounts of aluminum (400 meq/100 g, 80% neutralized) eliminated nearly all the exchange capacity of dioctahedral vermiculites and resulted in the formation of some gibbsite; the OH:Al ratio of the adsorbed $\text{Al}(\text{OH})_x$ was less than 2 and it was strongly adsorbed as its solubility was less than that of gibbsite.

The solubility product of gibbsite was determined at three temperatures and found to be $10^{-34.45}$ at 15°C; $10^{-33.96}$ at 25°C; and $10^{-33.52}$ at 35°C. A general equation for the solubility product of gibbsite at different temperatures is $\log K_{sp} = -\Delta H^\circ/2.303 RT + C$.

The chemistry of humic and fulvic acids extracted from soils developed under widely differing pedological and climatic environments was investigated by a variety of degradative procedures, including oxidation in acid and alkaline solutions as well as hydrolysis in base, acid, and water. Main types of degradation products, with maximum yields in parentheses, were: aliphatic acids (12%); phenolic acids (15%); and benzenecarboxylic acids (19%). Biologically derived $n\text{-C}_{16}$ and $n\text{-C}_{18}$ fatty acids constituted the bulk of the aliphatic compounds; most of the fatty acids appeared to be esterified to OH groups of phenolic constituents. Since about half of the degradation products were lost during the extensive fractionation and purification procedures employed, the three types of products mentioned above accounted for practically all the weight of the starting materials. Recent advances in instrumental analysis (especially the gas chromatography-mass spectrometry system) have provided, for the first time, powerful tools for the qualitative and quantitative analysis of humic 'building blocks.' However, much remains to be learned on how these combine and what types of structural arrangements are produced.

An experimental method which avoids biodegradation of samples was developed for measuring the Mn^{II} -fulvic acid complexing equilibrium.

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 Biochemistry

INTRODUCTION

The highlights of the Institute's research activities for 1974 are summarized here. The activities include studies on the mode of action and use of toxicants (fungicides, herbicides, and insecticides); the search for new target sites; and the isolation and characterization of biologically active material such as phytoalexins, insect neurotransmitters, and insect attractants and repellents that may have potential for use in crop protection. The study of these materials and sites and their utilization often requires a multidisciplinary approach and cooperation within our own institute and with other establishments in the Branch and elsewhere. The current pressure to replace persistent pesticides has made even more important the search for alternative pesticidal materials and the development of more effective integrated control programs for minimizing any deleterious effect on the environment.

This report and reprints of publications are available on request from the Research Institute, Research Branch, Agriculture Canada, University Sub Post Office, London, Ont. N6A 5B7.

E. Y. Spencer
Director

PLANT PESTS

Mode of Action of Selected and Potential Insect-control Agents

Activity was concerned with gaining more information on the mode of action of selected insect-control agents in order to use them more effectively and with searching for new target sites for potential insect control. In the former, further examination of DDT and several biodegradable analogues showed them to be strong inhibitors of mitochondrial respiration. DDT seems to be primarily an energy-transfer inhibitor, which would account for its inhibition of anion translocation.

After a decomposition product of the systemic fungicide benomyl was shown to be an inhibitor of cholinesterase, another systemic fungicide, thiabendazole, was studied and shown to have a weak reversible anticholinesterase activity and to be much less toxic to earthworms than benomyl. The enzyme glutathione transferase, which plays an important role in the detoxification of many inhibitors including certain organophosphorus insecticides, was shown to have an extensive range of substrates. A potent inhibitor of this enzyme has been designed and an analytical method has been developed for measuring the significance of the enzyme in the detoxification of isomers of some organovinyl phosphate insecticides.

Cytological investigations were continued on the European corn borer to find a basis

for determining the effect of drugs, hormones, and their analogues on the morphological changes in the insect, especially those leading to its death.

The new neurotransmitter substance proctolin, found in several species of insects, has been identified as a pentapeptide and its identity has been confirmed by synthesis. Several analogues were synthesized; all the analogues showed weaker activity and no antagonistic activity. Proctolin is highly active, initiating contraction at 10^{-9} to 10^{-10} M, and has a broader role than was previously anticipated.

Insect pheromones and attractants are expected to play an important role in the development of pest-monitoring techniques, thereby improving the effective use of insecticides and reducing the amount required. In this program, an electrophysiological method was developed that recorded a characteristic response (electroantennogram) that was more precise in measuring the two isomers of the sex pheromone of the European corn borer than were previous methods. This method was also used in evaluating the interaction of mixtures and related materials that were synthesized. The preliminary results emphasize the critical nature of the appropriate mixture of isomers for the strain in a particular location. In collaboration with the Research Station, Vineland Station, Ont., pheromone caps for monitoring the codling moth were analyzed and losses were correlated with locality and temperature. A mixture of

farnesene isomers was prepared and will be evaluated as a larval attractant and oviposition stimulant for the codling moth.

Work continued on the in vitro system of synthesizing chitin from grasshoppers. An improved experimental technique was developed for demonstrating chitin synthesis and studying the action of inhibitors such as polyoxins and certain substituted ureas.

Fumigants—Mode of Action, Use, and Residue Analysis

The discovery of resistance to residual pesticides in stored-product insects has increased the demand for counteracting this development and for improving the efficiency of insect control. Studies have shown that carbon dioxide potentiates the action of the fumigant phosphine in both normal and resistant strains of granary weevil so that the exposure period can be reduced to less than half. Enhanced toxicity was shown to coincide with increased uptake of fumigant, rather than increased respiration. Carbon dioxide was shown to disrupt oxidative phosphorylation, whereas phosphine inhibited electron transport. Field tests on the control of insects in the spouts of elevator bins with the use of phosphine were conducted. Upward air currents as they relate to the varying temperatures of the grain and the surrounding atmosphere were shown to be an important factor in the retention of lethal concentrations of gas at the points where infestation occurs.

To overcome the problem of deficient fumigation at low temperatures for controlling insects, laboratory studies have led to the development of formulations that give effective control at low temperatures (ca. 0°C), at which the toxicity of methyl bromide would have been previously greatly reduced. Eggs of the European red mite on apples can be eradicated with ethylene dibromide, but methyl bromide, ethylene oxide, acrylonitrile, and hydrogen cyanide are ineffective. When the fumigant is used at a rate that is toxic to the eggs, it does not injure the apples, and residue studies showed that most of the fumigant was desorbed from the pulp and skin after the apples had been held for 3 wk in cold storage.

The warning odor of phosphine has been shown to be caused by an impurity. Because this odor can be adsorbed during fumigation, extra care must be taken when you use this

fumigant after the warning odor has been removed.

Soil Insecticides—Ecological and Chemical Behavior

Problems encountered last year with a microsporidian infection in lepidopterous cultures were overcome and the cultures have been built up to satisfactory levels. Data were obtained on the toxicity of selected insecticides to the redbacked cutworm, corn rootworm, bertha armyworm, European skipper, Colorado potato beetle, striped cucumber beetle, crucifer flea beetle, and strawberry clipper, *Anthonomus signatus* Say. Laboratory and field studies were continued on the behavior, persistence, and degradation of promising soil insecticides. Studies on the development of resistance to insecticides showed that the redbacked cutworm has become resistant to the cyclodiene insecticides in Ontario, the northern corn rootworm is becoming resistant to chlordane, and the onion maggot is developing a low level of resistance to a wide range of organophosphorus and carbamate insecticides. Microplot and large-scale field trials were conducted to develop effective measures for control of the cutworm in field and vegetable crops, the carrot weevil, and the crucifer flea beetle. Studies on the biology of these insects under laboratory and field conditions were continued.

The study of the influence of certain cations on the reactivity of some insecticides in soil was extended to include bioassays of fensulfothion and other sulfoxide insecticides in an iron-treated sandy soil. A significant reduction in bioactivity related to untreated soil was found. However, iron had a minimal effect on the chemical persistence in sandy and muck soils. The persistence of parathion in muck soil and its uptake and metabolism in radishes were examined. Only parathion was detected in the soil and roots, whereas several phosphorus-containing materials including paraoxon accumulated in the leaves.

The influence of pH on the stability of five different classes of insecticides incubated over a range was examined.

The effect of insecticides on nontarget soil invertebrates was studied for a year to determine the effect of selected insecticides and a systemic fungicide on earthworms in pasture. This study and those on the comparative toxicity of selected insecticides to three

species of Collembola (springtails) and the larvae of one species of predatory carabid beetle have been completed. Although the toxicities varied, the residual effects appeared minimal after a single treatment.

During the study of microorganism-pesticide interaction, particularly the effect of insecticide-fungicide seed treatment on soybean plant growth, several *Rhizobium* cultures were isolated from soybean plant nodules. One isolate was used for further studies. It was shown that the insecticides chlorpyrifos and lindane and the fungicide thiram at rates as for seed treatment significantly inhibited the *Rhizobium* culture.

The effects of six insecticides on microbial activities and populations in a sandy loam were examined. Reactions differed between fungi and bacteria as well as between compounds. The influence of four nematocides on microbial activity including soil organic nitrogen was examined on soil from the tobacco fields of the Research Station, Delhi, Ont.

In the study of insecticide-plant interaction the observation that carbofuran enhanced plant growth was investigated. Carbofuran and its 3-hydroxy derivatives showed no growth-promoting activity in the absence of 2,4-D or indoleacetic acid (IAA), but stimulated growth in the presence of a low concentration of auxin. The discovery that 3-hydroxy carbofuran was more active than carbofuran suggests that it or another metabolite is responsible for the growth-promoting activity of carbofuran.

PLANT DISEASES

Mode of Action of Selected Fungicides

Major attention was focused on the activity of the new systemic fungicide Dowco 269 (Dow Chemical Co.) in relation to Phycomycetes. Little variation was found among species of *Phytophthora* in their sensitivity to Dowco 269 in vitro. Similar responses were shown by seven *Pythium* spp., but five others responded quite differently: two species were found to be very tolerant, the dose-response curve for one declined, and one was distinctly bimodal. Applied as a drench Dowco 269 was very effective in protecting pea seedlings against *Pythium ultimum*, but ineffective against *P. debaryanum* and *P. irregulare*.

As an outgrowth of studies on the mechanism of action of carboxin, where the target enzyme succinic dehydrogenase was implicated in the control of corn smut, structure-activity relationships were reexamined after several new carboxamides had been synthesized. From the results, it was possible to determine the molecular structure that is needed for inhibiting the mitochondrial succinic dehydrogenase complex. A close correlation was found between inhibition of the enzyme in vitro and the systemic activity of these compounds against plant disease. In a heterozygous cross that included a resistant mutant, the dicaryon showed considerable resistance if enough time was allowed between inoculation and carboxin treatment of the soil.

As part of a study on the mechanism of systemic action, the effect of pH on the uptake of the radioactively labeled systemic fungicide methyl benzimidazole carbamate (MBC) by corn roots showed that the ionized form penetrates more slowly than the uncharged material. Attempts are being made to increase the mobility of MBC into the plant by modifying its structure. The ability of a substance to penetrate is monitored by measuring its effect on root exudation. A simpler method of measuring permeability is by determining root pressure directly, applying enough counter pressure to the cut end of the root to just stop exudation.

Mechanism of Disease Development and Resistance

The potential of phytoalexins as fungicidal compounds has been clearly demonstrated by applying capsidiol, the phytoalexin from peppers, to tomatoes for the control of *Phytophthora infestans*. The results demonstrate the value of the fungicidal screening program, without which this development could not have been achieved. The importance of the screening program was further emphasized in the discovery of highly active compounds related to the phytoalexin orcinol from orchids, produced by chemical synthesis. These compounds were found to cause profound effects on hyphal tips, leading to rupture; possibly they actively interfere with the metabolism of the hyphal wall. They offer great promise as specific fungicides.

The investigation of phytoalexin production in *Solanum melongena* has shown relationships with other Solanaceae (potatoes, tomatoes, tobacco), and continuing work with *Datura* indicates that compounds from this plant also fit into the same biogenetic scheme. The principal phytoalexin, lubimin, was isolated and a structure, correcting a previous one, proposed. Work having broad implications is continuing on a study to formulate a general theory covering stress compounds in solanaceous plants.

Ultrastructural studies of resistant and susceptible interactions between pepper cells and pathogens have shown profound differences. Some of these differences have been correlated with capsidiol production in resistant interactions and it seems that capsidiol is probably produced fast enough to account for resistance. A monitoring system has been set up to search the current literature for reports on fungal and plant toxins that concern agriculture.

Because the chitin of the fungal cell wall is unique, its biosynthesis is being investigated in the search for new target sites. Conditions for protoplast formation from *Neurospora crassa* have been found, and the regenerative sequence can be followed by phase contrast microscopy and uptake of fluorescent dye.

WEEDS

Herbicides and Plant Growth Regulators

Previous work has shown that plant growth as affected by 2,4-D and other growth regulators was correlated with specific isoenzymes, and the enzymes associated with the membrane fraction have different characteristics from the soluble enzymes. Efforts are being made to improve the technique of isolating plant plasma membrane in order to better explain the effect of certain herbicides and insecticides on plant growth.

In the translocation of soil-applied herbicides such as atrazine, it has been generally assumed that translocation occurs in the transpiration stream to the shoots of the plants. However, it was shown that rather than just passing through the xylem vessels of the stem and petiole to the leaf blade, the herbicide accumulated extensively in the stems and petioles. The herbicide seems to follow a pathway similar to that for calcium and strontium. Transpiration was stimulated

by the addition of a nitrogen source such as urea or potassium nitrate.

In the study of herbicide-microflora interaction, recommended concentrations of linuron applied to soil not previously treated had no detrimental effect on test plants, whereas linuron applied to heat-sterilized soil or soil exposed to Vorlex (Nor-Am Agricultural Products Ltd.) considerably affected plant growth. The inhibition, however, was not always correlated with linuron concentration. By stepwise mutation with ultraviolet light, a bacterial isolate has been made that is sensitive to low concentrations of linuron and thus shows promise as a basis for a bioassay method.

ENVIRONMENTAL QUALITY

Management of Pesticides

The activities of this program include determining the extent of pesticide residues in soils, plants, and agricultural watersheds as a result of agricultural use of pesticides and developing more efficient methods of pesticide management that will result in more effective pest control with a minimum of environmental contamination.

The watershed studies were carried out in cooperation with the International Joint Commission Task Force C subwatershed program. Water samples were collected at intervals from some established and some new areas in southwestern Ontario. Analyses for pesticides showed that transport of DDT and atrazine was not proportional from the tributary to the whole system. Concentrations of insecticides in the waters were low in parts per trillion, consistent with earlier findings. The study at the Holland Marsh was continued with analyses for insecticide residues in soil, water, sediment, and fish. DDT in fish from the drainage ditch exceeded 5 ppm but fish from Cook Bay contained less than 0.25 ppm.

To determine if there was a residue from the use of protectant fungicides, various crops growing on three different soils in southwestern Ontario were checked for residues of dithiocarbamate and its breakdown products ethylene thiourea (ETU) and ethylene thiram monosulfide (ETM) and of captan and phaltan. Only muck soils from the Holland Marsh showed any residue of dithiocarbamate, whereas ETU and ETM

were not found. Only a vineyard showed any phaltan residue, whereas captan was absent.

Two programs aimed at developing more effective methods of pesticide management are in progress. In one program degree-days are being used to improve the timing of spray applications, and in the other a sex pheromone is being used to predict numbers of adult corn borers present. From the three localities in southwestern Ontario that were studied using the degree-day information for precise timing, effective control was obtained with carbaryl at London. Although the size of populations in the investigations at the other two locations presented problems, the

technique using the sex pheromone looks promising.

Good progress was made in the joint program with the Department of Environmental Biology, University of Guelph, to determine the feasibility of controlling the onion maggot utilizing the sterile-male technique. The mass-rearing technique was improved to boost production. A study of the use of a chemosterilant rather than radiation to induce sterilization gave promising results. At the small Keswick Marsh, where over 6 million sterilized flies were released, assessments showed very little damage to the onions, whereas damage was severe in the control area.

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Engineering Research Service Ottawa, Ontario

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Departure

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INTRODUCTION

Thirty-eight contracts were established this year as we continued to phase in the new national program on development, research, and evaluation of agricultural mechanization (DREAM). The projects contracted were those given the highest priority among proposals submitted from the various regions in Canada; total expenditure was \$400,000. The contracts support basic research and development work as well as evaluation of equipment and measurement of performance data. Contractors include universities, provincial government departments, industrial concerns, and independent organizations. Major areas of work that have been contracted include soil tillage, grain seeding and harvesting, mechanization of fruit and vegetable operations, forage harvesting equipment, waste and energy, farmstead equipment, and control of weeds.

Significant technology transfer was achieved through the preparation and distribution of 22 sets of plans and 75 leaflets by the Canada Plan Service, and through revision of the *Canadian Code for Farm Buildings*.

Technical consultations at national and international levels and the development of a number of instruments and items of equipment for research have contributed to transfer of research and technology.

This report summarizes developments in 1974. Additional information and copies of the publications listed may be obtained by writing to Engineering Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

Developmental Research

The Service continued to contribute manpower and equipment for research on forage harvesting by various systems at the Research Station, Melfort, Sask., but some planning and engineering activities concerned with feeding were taken over by the station's engineer. Hay for filling the hay tower was chopped to a longer length than previously; this solved some problems of dustiness and instability but adversely affected the distributor, so that filling was slower.

Data were collected for one season on the drying rate at various cutting widths of hay harvested with a self-propelled windrower and conditioner. After comparable curing periods and identical weather, the hay in swaths 2.4 m (8 ft) wide was about 3–5% drier than that in 4.9-m (16-ft) swaths.

More information was gathered on the effect of the type of crop and its moisture content on big-package systems (stacks, giant bales), as compared with silage and traditional bale systems. Three types of stackers were used to gain more experience of the losses caused by rain and wind.

A simulation analysis was expanded to include five systems for handling forage (wilted silage, giant bales, regular bales, chopped hay in a drying hay tower, and stacks). Simulation and analysis of western grain harvesting and handling systems continued.

Measurements and experience on injection of liquid manure between rows of growing corn at the Greenbelt Farm of the Animal Research Institute (ARI) led to preparation of a proposal for a front-mounted injector. The suggested design could eliminate many of the disadvantages of injectors now available for work in corn. Construction of a prototype will be requested on a contract to be issued through the Department of Supply and Services.

Data were obtained over 3 yr on corn silage losses and capacity of concrete tower silos 9 × 24 m (30 × 80 ft) in size at the ARI Greenbelt Farm. The data indicate that dry matter capacity is not dependent on the moisture content of silage, and confirm that the table that relates silage densities to depth, published in the *Canadian Code for Farm Buildings* (1970), gives a reasonable estimate of tower silo capacity. In 1974, the experiment was extended to include storage losses

and densities in large horizontal silos, with and without mechanical packing.

Studies on porous ceiling ventilation, started previously at Ottawa and Normandin, Que., were extended to include a free-stall barn for beef cows at Kapuskasing, Ont.; during the winter at Kapuskasing, barn temperature and humidity were controlled adequately when outside temperatures were as low as -29°C . A small NRC thermosiphon-type ventilation heat exchanger in a poultry building at the ARI Greenbelt Farm reclaimed about 7 kW heat energy from the exhaust air, giving improved cold weather ventilation.

Designs and prefabrication procedures were developed for structural ceiling diaphragms made of plywood or sheet steel. The diaphragms are intended to resist wind-storm forces on long rectangular farm buildings such as caged chicken layer units and hog finishing barns.

The Farm Building Standards Committee completed revisions for the *Canadian Code for Farm Buildings* (1975). A second edition of the *Canada Animal Waste Management Guide* was published; new material included manure storages from the Canada Plan Service.

A Canadian Government Specifications Board standard was developed for heavy-duty corrugated plastic tubing used for subsurface disposal of domestic sewage effluent. Preliminary results from a long-term study of field drainage at the Research Station, Harrow, Ont., and other research results on the structural performance of plastic drainage tubing were used in developing this standard.

Systems engineering analysis of alternative systems for handling dairy cattle manure confirmed the computer methods used but revealed the need for better input information. On-farm data were gathered on the way dairy free-stall manure is handled; barn scraping time for a 140-cow herd averaged 0.77 h/day, whereas loading and field spreading of 1-yr manure production, amounting to 2143 m^3 ($76,680\text{ ft}^3$), required 120 man-hours.

The program for measurement of runoff from feedlots and manure storage in Ontario continued. Pollution potential from applications of manure to land was further evaluated at sites on the ARI Greenbelt Farm and Central Experimental Farm.

Canada Plan Service

The Canada Plan Service (CPS) Design Center, in cooperation with the Information Division and committees of provincial extension engineers, prepared and distributed 22 new sets of plans and 75 catalog leaflets. The CPS plans and literature updated were mainly in the series on beef, dairy, sheep, and special structures; a particular aim was to replace the old bound catalog with new loose-leaf leaflets.

A 3-day course in CPS drafting standards and illustrative techniques was presented to four provincial design draftsmen (two from Ontario and two from Nova Scotia). One 2-day seminar outlining Code requirements and CPS structural design methods was presented to extension engineers from Alberta and British Columbia, and a 3-day seminar on controlled environment for animal production buildings was presented to the extension engineers from the government of Ontario and Ontario Hydro.

RESEARCH SERVICE

Equipment for Mechanization of Field and Laboratory Experiments

A table to convert pounds per bushel to kilograms per hectolitre was prepared for reporting cereal plot data in metric units. Drying rooms were designed to handle grain samples. Apparatus was designed to apply slurry treatments to seed. A hand-pushed precision fertilizer dispenser was developed. The Øyjord bulk feeder was evaluated for applying fertilizer and the Craftsman seed divider was tested in experimental plot seeder applications. The Oregon plot thresher was modified to process forage samples. A Hege cereal combine was adapted and tested for harvesting soybean test plots.

A photosynthesis chamber was constructed to maintain the environment of six individual plants at a selected temperature in the range of 1.5 – 24.0°C while CO_2 levels are monitored. A chamber, based on an upright freezer, was developed to test instruments at temperatures ranging from -20 to 27°C and controlled within $\pm 0.2^{\circ}\text{C}$. A portable dispenser was assembled to supply precise quantities of water to control humidity in tobacco curing chambers; water supply pressure was used to operate the mechanism. A

table oscillating at 0-5 cycles/min was assembled to agitate capsules containing pupae and their liquid diet.

Mechanization Applied to Crop and Animal Production

A seeder to plant narrow beds of "mini-carrots" was developed to increase harvesting efficiency and yield of this crop, and the Øyjord seeder was adapted for operation in horticultural nurseries. A six-row belt-type lifter for tree nursery stock was completed and evaluated, and use of waste from wood pulp processing as a mulch for nurseries was examined.

A system for harvesting and handling single-row whole-plant tobacco was developed and tested. The system minimizes manpower requirements in this normally labor-intensive operation; the plant is cut, chopped, and elevated to a bulk bin, which is then placed in a standard kiln or forms the kiln for curing the tobacco. Methods of drying whole-plant chopped tobacco in both laboratory and commercial quantities were evaluated, and a sugar cane cutter was tested and found useful for sorting the tobacco after curing. Systems for producing homogenized sheet tobacco were examined and a pilot plant system was proposed.

A harvest aid was developed to improve efficiency in harvesting apples for the fresh market. The apples are placed in bulk bins, which are elevated, transported through the picking platform, and unloaded mechanically. Preliminary trials showed that about a 50% greater volume of apples was harvested per man-hour with this system than by the conventional method with ladders. The machine is also being used as an aid in pruning fruit trees.

Systems were developed to record the rate of milk flow from individual cows in the milking parlor. Two kinds were made, one with use of a photoelectric detector and the other a capacitance probe. Means of identifying cattle were surveyed and recommendations made for Canadian conditions. Equipment for pumping cattle rumen to relieve bloat and grain overload was tested and improved.

Instrumentation

A new instrument for detecting catalase activity was evaluated to determine its functional reliability. A major breakthrough was

made in the development of instrumental techniques to identify cultivars of oat seed. Ground seeds are exposed to radiant energy at a wavelength of 2400 angstroms, which causes the sample to fluoresce. Spectral analysis of the emitted energy in the 3000- to 5000-angstrom wave band was found to discriminate between six common oat cultivars.

Processing and Quality Measurement

An instrument was developed to measure eggshell roughness by pneumatic techniques, to eliminate human errors when this quality factor is judged. Methods of monitoring egg weight standards were examined and a special scale was developed, but it was concluded that commercial top-loading balances provide the best results. Factors that affect the measurement of eggshell deformation to predict eggshell strength were measured and equations were developed to improve the accuracy of predictions by this empirical test.

Attempts were made to cut peaches by high-pressure water jet and laser, and the water jet was found to have potential application in processing fruits and vegetables. Systems were formulated for bruise detection and coring of apples. Maple sap and cranberry juice were concentrated by reverse osmosis and the process was found to be suitable for commercial applications. The effect of storage on firmness of onions and the influence of variety on firmness of tomatoes were measured.

An instrument was developed to measure the pressability of grapes. Friction between the test samples and the surfaces of texture-test cells was found to have a significant effect on the readings obtained. A simplified instrument was constructed for measuring the creep behavior of cheese, which gives an indication of firmness. Cohesiveness of gel-type products was measured by a new instrument that uses penetration to record rupture characteristics. A meat tenderness tester was constructed that enables samples to be tested rapidly. The Warner-Bratzler meat shear test was analyzed and the conclusions, supported experimentally, show that the meat is subjected to tension, not shear. An objective method was developed to measure textural characteristics of wieners and results were found to agree with sensory evaluations.

Methods of drying mushrooms were tested and an optimum process was recommended. The vapor pressure and moisture equilibria of rapeseed were established to provide basic data for the design of processing systems. The centrifuge used to measure the moisture-inhibiting properties of flour was further improved. Tests showed that readings from this instrument vary for a number of reasons and the method is useful only for preliminary screening tests because it is not very accurate. A means was developed to record the energy used to operate any laboratory extruder.

TECHNICAL AND SCIENTIFIC INFORMATION

The new program of agricultural mechanization has created new demands for background information, and searches were con-

ducted to locate related research and available information. Support was also provided for development and advisory programs within this establishment.

Improved classification and indexing schemes are being developed to provide better access to the section's collection of agricultural engineering documents. Many items can now be located either by key word or by general subject classification.

A compilation of agricultural engineering research and development projects being conducted in Canada was updated and published as ERDA Supplement no. 7.

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INTRODUCTION

During 1974 the recruiting for a team to work on ornamental plants was completed. This is the first time in the history of the Department that researchers on floriculture, nursery, and turf have been brought together with the full-time cooperation of a plant pathologist and an entomologist. During the year, good progress was made in identifying the major problems, and projects were started to solve them.

Evaluation of ornamental plants continued in the Arboretum and Botanic Gardens. The vacancy created by the retirement of the curator slowed down the overall program.

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ORNAMENTAL PLANTS

Floriculture

Promising mutations of the Rieger begonia and the rose cv. Forever Yours were induced by X radiation. Two mutants were obtained from *Begonia elatior* cv. Renaissance after irradiation with 3000 R. Rose cuttings exposed to 1500 R produced several color mutations of Forever Yours. The more promising mutations are being increased and evaluated for flower production and quality.

Cultural experiments on cyclamens showed that when they were grown at 18–21°C (65–70°F), they flowered earlier without significant reduction of quality and tolerated warm temperatures longer than plants grown at 13–16° (55–60°F). Enrichment of the greenhouse atmosphere with CO₂ enhanced growth at the early stages of plant development.

Gerberas grown in a soil temperature of 24°C (75°F) increased in yield by 23% and flowered 10 days earlier than plants grown in a soil temperature of 18°C (65°F). Diseases caused by soil-borne organisms were not observed on plants grown at the higher temperature, whereas plants grown at the lower temperature were affected by *Pythium* and *Rhizoctonia*.

Freesia grown under supplementary light for 16 h/day started to flower 3 wk earlier and had about 30% more flowers per plant and more florets per stem than plants grown under natural day lengths in winter.

Alstroemeria plants were grown under natural short-day conditions in the fall of 1973 without supplementary light. Under this regime cv. Regina remained vegetative, whereas Orchid initiated flower buds that

nearly all aborted before they were fully developed. During the fall of 1974, the plants were given supplementary light of 18.6 lx (200 ft-c) for 16 h/day. Under this regime Regina again remained vegetative, but Orchid initiated buds that continued to develop into normal flowers.

Tissue Culture

Callus cultures of tissue of *Cyclamen persicum* Mill. established on solid media grew rapidly and after 2 mo started to differentiate root and shoot initials. However the tissue did not develop into plantlets.

Meristem cultures of cultivars of *Begonia elatior* Reiger were also established on both solid and liquid mediums. The meristems grew rapidly, especially in the liquid mediums, and within 90 days plantlets with massive roots and shoots developed. The small plantlets were then transferred to solid mediums in culture jars. Contamination at this stage was extremely high, and attempts to reduce it by sterilizing the small plantlets were harmful to the tissue. Several alternate procedures are being investigated to reduce the high mortality rate of the begonia plantlets.

Physiology of Ornamental Plants

The experimental compound 2,3-dihydro-5,6-diphenyl-1,4-oxathiin shows promise as a disbudding agent for standard chrysanthemums. Spray treatment did not remove all lateral buds, but it reduced the number that must be removed manually. Timing, dosage, and varietal differences were major factors.

The use of benzyl isothiocyanate and other isothiocyanates as additives to other floral

preservative components increased significantly the vase life of cut carnations. This preservative activity appears to be related to the antimicrobial and ethylene synthesis inhibiting activities of the isothiocyanates.

Effects of the cut-flower preservative Flower Care varied significantly during the different stages of the production-marketing-consumer cycle. The vase life of cut roses was extended the longest when the preservative was used during the home consumer period. During the wholesale and retail marketing periods extension in vase life was shorter. The effects of the preservative were lowest during the immediate postharvest period. When the preservative was used during the wholesale and the home consumer periods, the final size of the flowers increased. A regression equation was used to calculate vase life at any concentration of preservative used.

Ornamental Plant Breeding

Weigela cv. *Purpurea* was selfed and crossed with Centennial and Dropmore Pink. Selfing of *Purpurea* yielded 22 seedlings with mainly purple foliage and 8 low-growing seedlings. The cross *Purpurea* × Centennial provided 22 seedlings with predominantly purple foliage but only one low-growing seedling. The cross *Purpurea* × Dropmore Pink produced 20 seedlings with chiefly purple foliage and 3 low-growing seedlings. The segregation of these characters is complex. Purple foliage seems to be partly dominant. Modifying factors mask the segregation of growth habit.

Evaluation of Annual Plants

The trials this year focused on garden geraniums, *Pelargonium hortorum* Bailey (42 cultivars were grown from cuttings and 50 from seed), petunias (356 cultivars), and *Phlox drummondii* Hook. (21 cultivars).

Geranium cv. Quest grown from cuttings scored the highest rating, and Eleanor and Sincerity were second. Sprinter was the best of the geraniums grown from seed, closely followed by three Carefree's, Deep Salmon, Bright Pink, and Crimson.

Because of weather favorable to *Botrytis*, the petunia cultivars with high resistance to the disease scored well. Of the 121 multiflora singles Plum Dandy, Groovy, Swissair Improved, and Resisto Rose-Pink were the best. Lavender Delight and White Empress were

the best of the 27 multiflora double group. There were 160 cultivars in the grandiflora single group with Rose Perfection and Sugar Daddy rating highest, and Floriday, Happiness, Midnight Star, Pink Cameo, and Pink Magic second. Of the 34 grandiflora doubles Blue Crown and Valentine were the best two.

Carnival Mixed and Extra Dwarf Beauty Crimson were the top rated in *Phlox drummondii* Hook., and Dwarf Mixed and *P. nana compacta* cv. Fireball were second.

Turf

Isobutylidene diurea as a turf fertilizer. Isobutylidene diurea (I.B.D.U.), an organic condensation product of urea and isobutyraldehyde (31-0-0), was tested as a slow-release fertilizer for turf. In the greenhouse, the N content of tissue of Fylking Kentucky bluegrass was higher during the first 30 days when grown at 19°C than at 10°C on Uplands sand and Grenville loam. However, after 30 days, the N content of tissue grown at these temperatures was quite similar. After 3 mo, the N content and total dry matter of plant tissue resulting from I.B.D.U. treatments were higher than those resulting from applications of ammonium nitrate. Applications of the fertilizer broadcast directly on turf were as effective for growth as similar rates incorporated initially with the soil. In both field and greenhouse experiments, a visible response was shown to particle size of applied I.B.D.U.: the larger the particle, the greater the response. In the field, at comparable rates of N, P, and K, turf quality and growth were similar to slow-release 10-6-4 in 1972 and superior in 1973 and 1974.

Persistence of native plant ecotypes as turf grasses. In 1965 some 35 native Kentucky bluegrass and fescue ecotypes were sprigged as turf grasses in a lawn, in order to study their establishment and persistency. The lawn was mowed regularly but received only minimal fertilization and supplementary watering. By 1974, two selections of *Festuca longifolia* Thuill., six of creeping red fescue, and seven of the Kentucky bluegrasses were still persisting vigorously. Thus many of our native ecotypes could be used for general purpose turf, particularly at low levels of management. Some of the fescue lines have since been used to formulate the cvs. Durlawn and Carlawn, introductions of the Canada Department of Agriculture.

Entomology

Development of a control program for the twospotted spider mite, *Tetranychus urticae* Koch, through the manipulation of its predator, *Amblyseius fallacis* (Garman), was continued. Because previous studies indicated that the frequent addition of small numbers of predators to the natural prey population might be effective in reducing prey abundance, the propagation of self-sustaining colonies of *A. fallacis* on a nonpest food was investigated. One method of propagation depended on constructing a food chain in which *A. fallacis* fed on the mite *Tarsonemus confusus* (Ewing), which, in turn, fed on a mold propagated on an agar medium. When the food chain was based either on the molds *Trichoderma* spp. or *Cladosporium* spp. propagated on a potato-dextrose medium, *A. fallacis* was reared through a complete life cycle on a culture of the predator maintained for 2 mo.

Diseases of Ornamental Plants

Tolerance for fungicide in Botrytis cinerea Pers. Damage caused by *B. cinerea* in outdoor beds of several ornamental plants was severe in the Ottawa region in 1974. Applications of the systemic fungicide benomyl did not control the disease. Isolation of the fungus from several hosts including begonia, geranium, snapdragon, marigold, viola, and zinnia yielded two cultures (one from begonia and the other from geranium) completely

resistant to high concentrations of benomyl in laboratory assays. In these assays, several other isolates were not completely controlled by this fungicide. The fungicide captan completely controlled the *B. cinerea* strain isolated from geranium, but several tolerant colonies developed when a spore suspension of the isolate from begonia was planted on a medium containing high concentrations of this chemical. Investigations are continuing in order to determine if resistance to fungicides is genetically acquired or exists because of a large number of physiological strains of the fungus already present in nature.

Persistence of *Pythium* in Artificial Growing Mediums

In artificial soilless mediums made up of various proportions of vermiculite, peat, and Turface, plus nutrients, *Pythium splendens* Braun persisted longer and produced more severe damage to rooted geranium cuttings than when the cuttings were grown in a sterile sand-soil-peat mixture. Results were obtained by planting artificially inoculated geranium cuttings in the various mediums and allowing the disease to cause complete necrosis. Healthy geranium cuttings were replanted in the same mediums at weekly intervals for 6 wk. Sufficient viable spores still remained in the artificial mediums after 6 wk to cause severe root rot. In the sand-soil-peat mixture only slight stunting occurred in healthy cuttings planted after 5 and 6 wk.

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Departures

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INTRODUCTION

In 1974, the Statistical Research Service provided advice and assistance on some 160 problems in the design of experiments and the analysis and interpretation of experimental data. Some advice was also given on nonstatistical mathematics. An increasing amount of time is being spent on the review of scientific papers, either before submission for publication or at the request of editors. All too often, review shows either that analysis of the data is inappropriate and inferences are consequently unjustifiable, or that their analysis is incomplete, which makes extra work necessary in subsequent studies.

Cooperation with other scientists in the Research Branch has continued to be close; because statisticians have been placed in several research stations, some of the problems sent to the unit have been more unusual than hitherto.

The library of computer programs has been further enlarged; programs have been added for the multiple regression of several dependent variables simultaneously on a predictor set; for multivariate analysis of variance for complete blocks; for factor analysis by unweighted least squares, generalized least squares, and maximum likelihood; for contour mapping; for two- and three-stage least squares; for the estimation of parameters in quantal bioassay when the number of objects exposed is a random variable, either Poisson or negative binomial; and for simple, partial, and total rank correlations. Subprograms of mathematical or statistical interest now available include Gram-Schmidt orthogonalization, singular value decomposition, and linear least squares regression with non-negativity constraints on the parameters. Existing routines continue to be improved as they are noted in publications or as newly recognized pathological situations arise.

For more information, correspondence should be addressed to: Director, Statistical Research Service, Research Branch, Agriculture Canada, Room E266, Sir John Carling Building, Ottawa, Ont. K1A 0C5.

L. P. Lefkovich
Director

Plant Science

A procedure developed to help potato growers anticipate outbreaks of late blight involves the use of a computer program, **BLIGHTCAST**, obtained from Pennsylvania State University and subsequently modified. Meteorological data are fed into the program, which then gives a recommendation to spray or not to spray. It was used successfully in the Thunder Bay region, where farmers reported the required meteorological data by telephone and received the computed recommendation only minutes later. A separate program is being developed to simulate the spread and decline of late blight in potatoes and to predict yield loss and relative gain under various schedules of fungicide application. Although the model used seems entirely adequate for any one year, it appears necessary to incorporate measures of year-to-year variability into this program to develop it further as a predictive tool.

In a comparative experiment on products used to extend the bloom life of cut roses and

other flowers, "Flower Care" (developed by CDA) was shown to be superior to its competitors. Its effectiveness also increased with increasing concentration.

The use of a compact design in a hill-spacing experiment on corn provided estimates of optimal combinations of spacing and number of plants per hill. The theory of these compact designs was further developed to give tests of homogeneity of variance for plots of different size and shape.

A new, easier, and faster laboratory method for estimating available aluminum and magnesium in soils produced values closely related to the concentrations in plant tissues, and also to the ratio of the yields of barley, rape, and buckwheat on unlimed and limed soils. This method can be used to determine the potential response of a soil to an application of lime. Other investigations on soil types and on plant uptake included studies of the relationships among soil mineral levels, lime requirements, and yields;

determination of a linear relationship between pesticide concentration and soil absorption that discriminates between soil types; analysis of an experiment to compare observers' abilities to interpret aerial photographs in terms of soil types; and analysis to compare levels of boron in the soil and in plant tissue.

Much collaborative work was undertaken with agrometeorologists, involving in-depth discussions of and comparisons among prediction equations, especially for cereal yield, soil moisture, and soil temperature.

Many comparative and breeding experiments were designed and analyzed. They included field tests of tobacco varieties and curing methods; diallel cross experiments on blueberries; studies to compare oil content and chemical composition of rapeseed varieties; nutrition experiments on pigs fed rapeseed; breeding trials for grain corn, silage corn, and soybeans; a forage harvesting experiment to compare drying rates; trials of fungicides for ornamental plants; and studies of the relationship between nematode counts and tomato yields.

Animal Science

Analyses of variance and covariance were applied to data from numerous studies of ruminant nutrition, including a series of experiments on the effects of selenium intake on growth and metabolism, and work on the effects of various rations on the carcass quality of dairy beef. Other data were analyzed from experiments on mineral metabolism in ruminants. In one experiment, the results of chemical analyses of hair from the experimental cattle were used to determine whether dietary mineral levels were adequate. Statistical advice was given on the design of a large-scale experiment to study pasture management in cow-calf operations, and also on the analysis of data from an unbalanced diallel cross experiment with sheep.

The effect of early weaning of lambs on their growth rate and the interaction of age at weaning with breed, sex, age of dam, litter size, and year were estimated from a long-term experiment. Estimates of genetic parameters were also obtained from this study. Regression techniques were used to predict total muscle and muscle-to-bone ratio from carcass traits measured both ultrasonically on the live animal and directly from the carcass.

Ultrasonic measurements were poorly correlated with the corresponding carcass measurement but quite highly correlated with total muscle and muscle-to-bone ratio.

Data on the effect of various rations on development of the reproductive tract of prepubertal gilts were analyzed. Other studies of swine nutrition included feeding trials to evaluate field peas as a protein source in swine rations, and experiments to estimate the effects of feeding high levels of corn oil on the maternal performance of sows. Inbreeding coefficients were computed for 21,000 pigs from 10 generations, in a swine selection experiment.

Analyses of data from a poultry experiment showed that adult roosters were a suitable alternative to chicks as experimental animals for estimating the metabolizable energy in various poultry rations. The precision and reliability of a machine for measuring the shape index of eggs were calculated in terms of variance components. The machine is more precise than previous methods, the major source of variation now being differences in the shape of eggs and not the variation among observers. In other studies, regression methods were used to find an equation to predict fracture force from various characteristics of eggs, and also to predict eggshell thickness from pressure measurements. Other poultry studies concerned the intake of calcium supplements from various sources and with differing textures; the influence of age and season on egg weight; and the effect of vaccination on the incidence of Marek's disease.

Food Science

Advice was given on the design and analysis of sensory evaluation experiments. An experiment for consumer testing of meat, aged and cooked in various ways, was designed so that the statistical analysis can eliminate carryover effects from one tasting to the next.

Data from scaled preference and ranking tests on cheeses made with two kinds of enzyme were examined and found unsuitable for statistical analysis; a more appropriate experiment was designed. Another experiment compared bovine pepsin with calf rennet used in cheese making at an industrial scale; different factories prepared these cheeses. The experiment demonstrated some

statistically significant but small differences in several aspects of the cheeses.

Bioassay

Collaborative work continued on the bioassay of bluetongue virus, by a plaque neutralization method. The disadvantages of low control counts were demonstrated and experiments were carried out to establish an optimal range. Further variability studies showed differences between successive aliquots, perhaps attributable to surface tension; the experimental techniques were modified accordingly. An accepted method of analysis for cross-reaction data was found to give a biased estimate of variance, and to yield misleading estimates of symmetrical differences. After the method had been modified, different degrees of relatedness were found among six strains of the virus.

The analysis of the data from a long-term study involving dilution assays of denitrifiers in soil was made more flexible, and more thorough, by adaptation of one of the unit's standard programs instead of using tables restricted to particular designs. More efficient designs for future experiments were suggested.

Ecology

A study of the sex ratio of the European red mite showed that this value varied significantly from orchard to orchard, and from tree to tree within orchards, but was dependent neither on the density of the mites nor on the variety of apples.

Data for a large study of predator-prey interactions among mites have yet to succumb to analysis. Cross-spectral analysis failed, as did other analyses, because of the low counts of predators; attempts will now be made to model the prey population and to predict predator activity from the lack of fit.

An attempt was made to relate the number of moths caught at night to the phase of the moon and to various measures of temperature and humidity. The results showed that the phase of the moon was an unsatisfactory measure of the amount of light and was unimportant as a predictor. However, various candidate summaries of both temperature and humidity were equally satisfactory as predictors and served to explain some of the differences in catches as well as among the traps.

Experiments to examine the relationship between the attractiveness of queen bees and the success of a hive did not yield a real association; a better measure of attractiveness will be sought.

A theoretical study was made of the use of sequential methods to estimate the mean of a negative binomial distribution, a frequent problem in insect ecology. It indicated that these methods can provide equal precision with less field work than previously required.

Numerical Taxonomy

Theoretical studies on techniques of non-hierarchical, non-disjoint classification have led to the implementation of an efficient algorithm, and to the measurement of the results of clustering in a loss function framework. The extension of the latter results to hierarchical disjoint techniques is under investigation.

In collaboration with the Biosystematics Research Institute, formulas were sought to express the relative values of hierarchical classifications on the basis of their general shape, independent of the actual taxa involved. Attempts to achieve this by reference to an "ideal" tree were found to depend too heavily on distance concepts. A statistic based mainly on the number of branches at each node is being adapted to reflect asymmetry and to give consistent results when nonessential nodes are excluded.

Canonical analysis was very useful in three taxonomy problems. Classification of populations of *Cannabis sativa* L. into groups, such as wild versus cultivated or intoxicant versus nonintoxicant plants, was only weakly supported by a canonical analysis of their morphological aspects. Classification of birch based on genetic considerations and geographical locations across Canada was sustained by canonical analyses of several morphological traits. A great difference in nonspecific esterase isozymes between the cutworms *Euxoa campestris* (Grote) and *E. declarata* (Walker) was confirmed by canonical analysis of the band patterns. Interestingly, the canonical axis of the hybrid of the two species revealed a reciprocal difference between them.

An improved method using geometric techniques was proposed to estimate the number of pores on a pollen grain from microscopic observations of part of the grain. The half-widths of oat seeds were analyzed

to determine whether this character could be used to distinguish among various cultivars, and also whether this character depends on the breeding status of the cultivar and on the environment in which it is grown. The results so far obtained seem promising.

Data on several species of the family Chironomidae were analyzed in terms of geographical and temporal differences, and revealed local temporal differences of the same order as geographical ones.

PUBLICATIONS

Research

- Binns, M. R. 1974. Approximating the negative binomial via the positive binomial. *Technometrics* 16:323-324.
- Binns, M. R. 1974. A double sampling procedure to control the variance in net weight acceptance sampling. *Technometrics* 16:539-544.
- James, W. C., Shih, C. S., and Callbeck, L. C. 1973. Survey of fungicide spraying practice for potato late blight in Prince Edward Island, 1972. *Can. Plant Dis. Surv.* 53:161-166.

Miscellaneous

- Binns, M. R. 1974. A sequential counting procedure for estimating the total number of randomly distributed individuals. Tech. Rep. 82, Dep. Statistics, Stanford Univ., Stanford, Calif.

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Plant nutrition
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INTRODUCTION

This report is a brief description of research activities in 1974. Research in animal science emphasizes breeding and physiology of beef cattle, swine, and poultry; and in plant science, breeding, physiology and management, soil fertility and plant nutrition, cultural practice, and weed control.

Dr. K. W. Campbell was appointed in December to increase efforts in barley breeding research.

Mr. R. D. Dryden was appointed for a 2-yr term as Canadian Expert for the India Dryland Project at Hyderabad, India, and Dr. E. D. Spratt continued to serve as Canadian coordinator for the project.

Only the highlights of research are presented in this report; for further information concerning details of work discussed or on related subjects, enquiries should be directed to: Research Station, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Performance of foreign × domestic hybrids. Hybrids representing 10 breed combinations (Limousin, Simmental, and Charolais × Hereford, Angus, and Shorthorn, plus a Hereford × Angus cross as control) were evaluated as first-calf heifers in contrasting environments at Brandon, Man., and Lethbridge (Manyberries), Alta. The heifers were allocated to the project in 1971, 1972, and 1973 and in each case produced their first calves at 2 yr of age. Red Angus and Beefmaster bulls were used for the matings by artificial insemination over a 9-wk breeding season each year. Estrus was detected on average in 98% of the heifers, and 84% of these conceived to an average of 1.4 services per conception. No significant differences were observed in detection or conception rate between breeds of sire, breeds of dam, or locations.

Gestation averaged 282 days for all heifers and ranged between 280.4 and 283.8 days for specific hybrid combinations. In 1972 and 1973, 801 calves were born; 57% of the males and 80% of the females had unassisted births. Sex of calf influenced calving ease, and births of 14% of the males and 4% of the females were recorded as difficult (including four by Caesarean section).

Pre- and early post-natal mortality was higher among males than females (5.0 vs. 3.6%), as was the occurrence of weak calves (4.9 vs. 1.1%). Survival to weaning for calves

from all "exotic" × domestic heifers was 91.0% compared with 93.4% for calves from the Hereford × Angus heifers. The exotic crossbred heifers tended to produce significantly heavier calves at birth and weaning than the Hereford × Angus heifers. Simmental-sired heifers weaned heavier calves than Charolais- and Limousin-sired heifers, and heifers from Shorthorn dams weaned heavier calves than heifers from Hereford and Angus dams. Evaluated on the basis of number and weight of calves weaned per 100 heifers assigned for breeding, Hereford × Angus heifers were marginally better than the best of the exotic hybrids, and 10% better than the Limousin-sired hybrids and the hybrids out of Hereford dams. Evaluated in terms of the weight of calf weaned as a percentage of the dam's weight at calving, cow efficiency was 49.2% for the Hereford × Angus heifers compared with a range of 45.9% (Charolais × Hereford) to 51.7% (Simmental × Shorthorn) for the exotic hybrids.

Calves sired by Red Angus bulls were less subject to calving difficulty, early mortality, and weakness than those sired by Beefmasters, but they weighed about 40% less at birth. Differences attributable to the two environments were negligible. For their second, third, and fourth calvings, the same hybrid cows are being mated to Limousin, Simmental, Charolais, and Chianina bulls by restricted randomization to avoid backcrossing, so that their productivity as mature cows can be evaluated and compared.

Effect of rate of chilling on muscle quality. Left and right sides of 27 carcasses from crossbred steers were chilled at two temperatures (0.6 vs. 7.2°C) to evaluate the rate of decrease in muscle temperature and the rate of muscle glycolysis. Temperature and pH readings were obtained 45 min after slaughter, at six 4-h intervals, and 48 and 72 h post mortem. Muscle samples for shear tests and taste panel evaluation were prepared and frozen 96 h post mortem. Internal muscle temperature decreased more slowly and pH decreased more rapidly at the higher chilling temperature (7.2°C). Steaks from the sides chilled at the higher temperature were rated significantly higher ($P = 0.01$) for tenderness and flavor and were favored over their paired counterparts 80% of the time. Tenderness was the major reason for preference in 71% of the samples, whereas flavor was the main reason in 15% and juiciness in 14%. There was no significant difference in the juiciness of steaks from sides chilled at either temperature.

Swine

Effect of selection on reproduction and early mortality. Litter size at birth and weaning was unaffected by selection for postweaning average daily gain over 12 generations of swine. Genetic gains of 0.15 and 0.16 kg/generation were realized in the selected and crossbred groups (the latter sired by males from the selected population). Correlated responses for preweaning average daily gain (0.0041 and 0.0043 kg/day per generation) were realized in the selected and crossbred populations. Length of gestation showed a small but significant regression ($b = 0.1$) in the random-bred control and crossbred groups. With few exceptions, the selected population had more stillbirths and deaths attributable to the sow and other causes of preweaning mortality. For the selected, control, and crossbred populations the data were: stillbirths, 7.3, 3.2, and 1.9%; deaths attributable to the sow, 6.7, 4.1, and 4.7%; and other causes, 9.2, 4.6, and 3.7%. Regression analysis showed no time-dependent change in mortality, which indicates that selection did not adversely affect this trait.

Effect of ejaculation frequency on semen characteristics, conception rate, and embryonic survival. In a changeover experiment, semen was collected from 18 Yorkshire boars (average age 13.5 mo) at 24- and 72-h

intervals. There were smaller semen volumes (161 vs. 195 ml), fewer spermatozoa/ml (99 vs. 221×10^6), and fewer spermatozoa/ejaculate (11.2 vs. 32.1×10^9) for ejaculates collected on the 24-h schedule than on the 72-h one. The percentages of motile spermatozoa were similar (76 vs. 80%) for both collection schedules.

Primiparous Yorkshire sows were artificially inseminated on the 2nd day of standing estrus with 100 ml of the semen (diluted with an egg-yolk, citrate, and catalase extender), containing 2.5×10^9 motile spermatozoa. Insemination took place at the first estrus (83 sows) or second estrus (94 sows) after weaning and the sows were killed 24 to 26 days after breeding. Fertility data of sows inseminated with semen collected at intervals of 24 h (84 sows) and 72 h (93 sows) were: conception rate 83 vs. 70% ($P < 0.05$), litter size 9.9 vs. 10.0, and embryonic survival (live embryos/no. of corpora lutea $\times 100$) 73 vs. 76%. The among-boar correlation of conception rate and embryonic survival was 0.85 ($P < 0.05$). The ovulation rate of sows averaged 13.5 and 14.8 ova on first and second postweaning estrus. Ovulation rate was higher ($P < 0.05$) in sows that did not conceive than in sows that did (16.5 vs. 13.5).

Response to selection. In a Lacombe swine population after 11 generations of recurrent mass selection for postweaning average daily gain, the predicted response to selection was 0.241 ± 0.023 , the observed response 0.128 ± 0.016 , the estimated heritability 0.327 ± 0.031 , and the realized heritability 0.173 ± 0.021 . The estimate of observed response was 0.53 of predicted response.

One major aspect of the study was the relative effect of selection in the Lacombe population on performance of the crossbred progeny, when males from the selected population were mated with Yorkshire females from a random-bred control population. Regressions of performance on time were 0.0116 ± 0.0014 for the Lacombe and 0.0065 ± 0.0011 for the Lacombe \times Yorkshire crossbreds ($P < 0.01$ in both cases). This indicates additive gene action, and improvement in the crossbred progeny can be obtained by selection in the parent population. This is verified by comparison of the expected progress (0.0629 ± 0.0272) and observed progress (0.0710 ± 0.0119) in the cross based on selection in the Lacombe population.

Poultry

Dwarf versus normal broiler breeders. No difference was found in egg production to 329 days of age between half-sib normal (DW) and dwarf (dw) broiler breeders housed in floor pens (48 vs. 47%). Dwarfs in cages produced at a lower rate (40%). Whether in floor pens or in cages, dwarfs consumed much less feed per dozen eggs than their normal half-sisters (3.35 vs. 4.30 kg). There was little difference in the age at which they attained 50% production, although the dwarfs tended to commence laying earlier.

At 8 wk of age, female offspring from matings of a normal commercial male with normal and dwarf half-sib females grew at similar rates (1704 and 1713 g) and had feed conversion rates of 2.46 and 2.53 kg/kg of body weight. Males from the normal \times normal matings differed slightly from those from normal \times dwarf matings in growth rate (2165 vs. 2092 g) but were similar in feed conversion (2.30 vs. 2.33 kg/kg of body wt).

PLANT SCIENCE

Forage Crops

Yield, chemical composition, and growth response to sources of fertilizer nitrogen. Annual applications of N in the early spring to bromegrass and timothy (hay species) and to Russian wild ryegrass and crested wheatgrass (pasture species) increased and prolonged vegetative growth; increased protein, phosphorus, potassium, and other minerals in the plants; and produced faster regrowth after harvest. Urea and NH_4NO_3 were better sources of N than solution N (50% urea and 50% NH_4NO_3) and sulfur-coated urea (SCU), in terms of the quantity and quality of forage produced. When N was applied at 134.4 kg/ha as urea or NH_4NO_3 , vegetative growth was prolonged 10 days, and dry matter accumulation (DMA) averaged 40% on July 6 (second harvest) compared with 48% for unfertilized controls and 45.6% for forages that received solution N and SCU. The four species were ranked in decreasing order of DMA as crested wheatgrass, Russian wild ryegrass, bromegrass, and timothy.

All N sources were more effective in promoting growth and nutrient uptake under adequate moisture regimes and on clay or

loam soils than under conditions of high moisture deficits and on sandy soils. Urea was a better source of N than NH_4NO_3 for promoting growth, quality, and nutrient uptake on sandy soils, but on clay and loam soils the two sources of N were equal. When only the two better sources of N were compared, bromegrass and crested wheatgrass responded better to NH_4NO_3 , whereas Russian wild ryegrass and timothy responded better to urea. With the two poorer sources, the hay species (bromegrass and timothy) responded better to solution N, whereas the pasture species (Russian wild ryegrass and crested wheatgrass) responded better to SCU.

Protein and mineral composition of the four grasses decreased progressively through four harvests taken at monthly intervals from June 6. The largest and most rapid decrease occurred in the hay species, in which protein was reduced by 50% between June 6 and July 6, compared with 40% in the pasture species.

Yield and protein content of grasses and legumes with nitrogen, sulfur, and micronutrients. No yield response was obtained when micronutrients were applied to grasses and legumes. Annual application of S increased the yield and protein content of alfalfa, and annual applications of S and N increased yield and protein content of legumes and legume-grass mixtures.

Nitrogen status of the soil under crop and fallow. Soil temperature, rainfall, and plant growth directly affect the N status of the soil during the growing period. Before growth started in spring and after it ceased in the fall, soil temperature and moisture were the most important influences. When soil moisture was at field capacity, warm temperatures resulted in formation of NO_3^- -N. When the soil was saturated by rain NO_3^- -N was leached, and when it remained saturated for 24 h or more, denitrification probably affected the N status most, particularly at soil temperatures above 15°C. Below 15°C, immobilization of NO_3^- -N was more important than denitrification. Under cropping, uptake of soil N by plants tended to modify these processes. However, in the early stages of growth N might become unavailable to crops because of leaching, denitrification, immobilization, or a combination of these processes. After harvest or at the soft-dough stage (in cereals), NO_3^- -N began to increase in the soil

at a rate dependent on soil temperature and soil moisture.

Oilseed Crops

Nutrient requirements of fababeans. In a preliminary study, fababeans responded to application of fertilizer that supplied K at rates up to 200 kg/ha. There was a small response to P at 9 kg/ha, but the plants used only a small part of the inorganic P applied and on one soil yields decreased with P at 18 kg/ha. When $\text{SO}_4^{2-}\text{-S}$ was less than 5 ppm in the top 15 cm of soil, plants responded to application of S at 20–40 kg/ha. There was response to molybdenum applied as a foliar spray (0.5 kg Mo/ha) and to copper applied as a soil additive (10 or 20 kg Cu/ha). Addition of N resulted in decreased yields and poor or absent nodulation.

Effects of residual phosphorus and micro-nutrients on yield and composition of flax. When flax was grown on a Waskada clay loam and on a Carroll clay, straw and seed yields increased as soil P increased to 10 ppm (as determined with 0.5 M NaHCO_3). As P levels increased from 10 to 18 ppm, concentrations of Zn in plant tissue at the dough stage became marginal (< 20 ppm) and those of Cu became deficient (< 6 ppm). However, yields did not increase after applications of nonchelated Fe, Mn, and Zn at 4 kg/ha and Cu at 1 kg/ha.

In the growth chamber, on the Waskada soil, flax yields at 50% bloom increased from 0.48 to 0.57 g/plant when P was applied at 50 kg/ha and to 0.77 g/plant with P at 50 kg/ha, Zn at 12 kg/ha, and Cu at 3 kg/ha. In other tests, application of Zn at 10 and 20 kg/ha, as ZnSO_4 and as Zn chelate, tended to reduce yields of flax seed and straw.

Weed control in flax. AC 92553 (Cyanamid of Canada Ltd.) at 1.65 kg/ha and EPTC at 3.36 kg/ha as preplant incorporations gave excellent control of wild oats and green foxtail and produced a significant increase of 31% in yield of flax. Asulam at 1.12 kg/ha and in combination with other herbicides gave good control of grassy weeds but suppressed flax growth slightly. The detrimental effects of MCPA in asulam mixtures for wild oats in flax were less severe than previously noted. HOE 23408 (Canadian Hoechst Ltd.) at 0.84 and 1.68 kg/ha and asulam at 1.12 kg/ha increased flax yields 13 to 30% over those from untreated plots.

Soybean production. Preliminary trials were continued to evaluate the potential of soybeans on the eastern prairies. Breeder lines from Ottawa, Guelph, and Harrow, Ont., Morden, Man., and St. Paul, Minn., were planted on May 27 and harvesting commenced in late August. Several lines reached full maturity with less than 1,800 heat units (from time of emergence to 15% kernel moisture). All entries in the U.S. Department of Agriculture 00 regional trial reached maturity successfully and yielded on average 1.36 t/ha. The lines varied widely in determinate habit of growth, height of pods, flowering date, plant height at maturity, shattering, and branching. Studies with rhizobium cultures as they affect nodulation and yield gave inconclusive results.

Weed control in fababeans and lentils. Preplant incorporation of trifluralin at 0.83 kg/ha gave excellent control of grassy weeds in fababeans and resulted in yields that were threefold those of the untreated control. Barban at 0.35 kg/ha and triallate at 1.68 kg/ha provided good control of wild oats but were less effective against green foxtail, and lower yields were obtained.

HOE 23408 at 2.24 kg/ha and EPTC at 3.36 kg/ha controlled wild oats and green foxtail and doubled the yield of lentils over those from untreated plots.

Weed control in rape. Five dinitroanilines at 1.4 kg/ha were incorporated into the top 7.5 cm of soil as preplant herbicides for the control of wild oats and green foxtail in rape. Triallate controlled wild oats only but fluchloralin, CGA 10832 (Ciba-Geigy Agricultural Chemicals), trifluralin, and dinitramine gave excellent control of both weeds. Dinitramine impaired germination of rape and yields were reduced. HOE 23408 at 1.1 kg/ha gave excellent control of both common weeds, and rape yielded 60% more than on untreated plots.

Cereal Crops

Barley breeding. Emphasis continues on improved yield, agronomic excellence, and disease resistance in six-row malting and feed barleys. Some advanced lines with good malting characteristics continued to perform well despite adverse conditions. One line outyielded Bonanza by 13%. A selection from this line, which is resistant to stem rust, loose smut (old races), and *Septoria*, has a

yellow aleurone and will be tested further in 1975.

Two feed barley selections continued to perform well in advanced tests and one outyielded Bonanza by 15%. Work continued on lines that contain high levels of amylopectin and lysine, and several crosses and lines contain the *Un*, *Un* 8, or *Valki* genes for resistance to loose smut. Two genetic marker stocks have been isolated, each with at least one gene on each chromosome. One stock carries the dominant genes and the other the recessive alleles.

Solution nitrogen mixed with herbicides for wheat. Tank mixtures of solution N (28-0-0) applied at four rates (0, 22, 45, and 67 kg/ha) in combination with barban, triallate, and WL 29761 (Shell Canada Ltd.), each at three concentrations, were compatible except that the mixtures of barban with solution N caused leaf burn at first. All herbicides gave good control of wild oats and resulted in wheat yield increases of 6-18%. Solution N produced a 10% yield increase at 67 kg/ha but no increase at other levels.

Granular N applied at seeding was preferable for wheat and increased yields by 15%, whereas solution N applied at the three-leaf stage of growth increased yields by 8%. Averaged over both formulations, N at 22, 45, 67, and 90 kg/ha increased yields by 19, 37, 39, and 45%.

Weed control in wheat and barley. HOE 23408 at 0.84 to 2.24 kg/ha gave good control of wild oats and green foxtail with resultant yield increases in wheat and barley. WL 29761 at 0.42 to 1.12 kg/ha gave excellent control of wild oats in wheat and rates as low as 0.63 kg/ha equaled 1.4 kg/ha of benzoprop, a previously recommended analogue for which timing of application is critical. Of six mixtures tested, only bromoxynil with MCPA (0.42 kg/ha) and bentazon (0.42 kg/ha) could be mixed with HOE 23408 (1.12 kg/ha) without weakening the weed control properties or causing injury to barley.

Corn production. Heat unit (HU) accumulation from emergence to killing frost was below normal (1,943 vs. 2,150 HU) because of delayed planting and slow germination. Precipitation was lower than the long-term average (22.5 vs. 30.5 cm) and distribution was poor throughout the growing season. Yields in evaluation trials were lower than

for previous years, mainly because of a lack of maturity (percentage kernel moisture) and low test weight in grain hybrids. Dry matter yield of silage corn was also affected but to a lesser degree; average test yields were 7.1 t/ha although the goal was 11.2 t/ha. However, despite the abnormal year some genetic material produced a grain yield of 4.08 t/ha and test weight of 72 kg/hl. Shelterbelts continued to be advantageous at Indian Head, Sask., where silage yields were 7.3 t/ha compared with 5.0 t/ha on exposed sites; the 3-yr averages were 7.5 and 4.8 t/ha for sheltered and exposed sites.

Corn silage production was assessed in economic terms in comparison with barley and was shown to be the better at various levels of production, values of barley grain, and animal performance.

Effect of macro- and micro-nutrients on yield and composition of corn. Despite low levels of 6 to 8 ppm P (0.5 M NaHCO₃) in Almassippi very fine sandy loam and in Altona fine loam, yields of corn did not increase with applications of 14 to 28 kg P/ha. Concentrations of P in ear leaf tissue from control plots, at tasseling, were high (0.33 and 0.31 ppm for the two soils), which throws doubt on the validity of current soil testing procedures for all soil types. Levels of K in the two soils were high (150 and 148 ppm) and concentrations of K in the ear leaf tissue were 2.41 and 2.19%. Concentrations of Zn in ear leaf tissue were marginal (< 20 ppm in both soils), and although application of Zn chelate at 0.63 kg Zn/ha increased Zn levels in plant tissue from 16 to 18 ppm and from 18 to 24 ppm on the two soils, it did not increase yields. Applications of Mn and Cu fertilizers did not increase yields but concentrations in leaf tissue were adequate (93 to 104 ppm Mn and 8.1 to 11.1 ppm Cu).

Weed control in corn. Preplant herbicides incorporated in the soil provided reliable control of wild oats, green foxtail, and broad-leaved weeds. Yields three times those of untreated plots and even exceeding those of hand-weeded plots were obtained with S6176 (Gulf Oil Canada Ltd.) applied at 5.2 kg/ha. The other herbicides tested, EPTC at 3.4 to 4.5 kg/ha, butylate at 3.4 kg/ha, and vernolate at 4.5 kg/ha, each mixed with a protectant (R 25788; Stauffer Chem. Co.) alone or with atrazine, controlled weeds well and produced significant increases in yield of

corn. These herbicides did not injure the corn.

Sorghum production. In preliminary tests with sorghums, lines obtained from the CIMMYT collection and from private companies were evaluated for photosensitivity

and performance. The species is similar to corn in its response to climate. None of the CIMMYT lines completed anthesis and set seed, but some early experimental selections such as X4004 and X4053 (Pride) achieved maturity.

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All-Indian Coordinated Research Project for
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INTRODUCTION

This report summarizes research in field, oilseed, vegetable, and new crops as well as ornamental horticulture at the Research Station, Morden, Man. Several cultivars were named and released in 1974: two chrysanthemums, Morden Everest and Morden Eldorado; a *Physostegia*, Morden Beauty; a large-seeded buckwheat, Mancan, developed specifically for the export market; and two cucumber hybrids, Earlimor and Alouette. A flax selection that is resistant to the new races of rust was identified and merits release. Other significant events included the establishment of cooperative projects between the corn program at Morden and several European corn breeders; joint projects on new crops with the Manitoba Department of Agriculture and the Manitoba Research Council; the secondment of Dr. E. D. Putt to CIDA for one year to advise on sunflower research and production in India; and the appointment of Dr. H. Huang, a plant pathologist, to strengthen studies of sunflower diseases.

Additional information can be obtained from the Research Station, Research Branch, Agriculture Canada, Box 3001, Morden, Man. R0G 1J0.

D. Gordon Dorrell
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FIELD CROPS

Buckwheat

Breeding. Mancan, a large-seeded diploid variety, previously designated as MB1, was licensed in 1974. Three dwarf mutants have been isolated, and inheritance and allelic studies are being conducted. Hull percentages of advanced lines showed that those having larger seeds have a higher percentage groat. A test to determine the effects of cross-pollination between diploids and tetraploids showed no detrimental effects from cross-pollination.

Disease. *Alternaria alternata* (Fr.) Keissler was isolated from chlorotic leaf lesions and *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur from tan stipplelike spots. *A. alternata* was not pathogenic. However, *C. sativus*, which is also seed-borne, caused stipple spot. A foliage disease, caused by *Botrytis* sp., appeared late in the season after wet weather. This disease was widespread in research plots at Morden and Portage la Prairie, Man., and in commercial fields. Although the disease usually did not reduce yields, one large increase plot showed about 50% reduction in seed yield.

Management. The cultivars Tokyo and Tempest were sown on three dates (at the beginning, middle, and end of June) and at four rates (9, 18, 36, 72 kg/ha) in a 3-yr study. Lodging was higher in Tempest than in Tokyo and it usually decreased with higher

rates of seeding. Yields decreased with each 2-wk delay in seeding date. Yields increased with higher rate of seeding in 1971, did not differ in 1972, and increased at all seeding rates up to 36 kg/ha in 1973. Seed size decreased with each delay in seeding but did not differ with seeding rate.

Corn

Breeding. Over the past 3 yr, Morden 74201 averaged 22% higher grain yield and 3.1% lower moisture content at harvest than the average of the controls.

Several synthetics have been developed that are expected to produce, by selection, inbreds with greater resistance to stalk rot and better early vigor. A cooperative program has been arranged with several European breeders to exchange inbreds and segregating material. Heterozygous material from Morden will be sent to Europe to select for resistance to stalk rot and for early vigor. Selection for these traits appears to be more readily accomplished under the European climate. European material will be grown at Morden to select for adaption to our climate.

Disease. Root rot in young plants was a common occurrence, which killed many plants during the dry, hot weather in July. The excessive moisture in spring is believed to have favored the development of this disease.

Management. Tillering corn hybrids grown at lower populations (50,000 plants/ha)

yielded more total dry matter than did nontillering types. At higher populations, the yield of the tillering types showed no advantage because tillering was severely suppressed.

Field Peas

Breeding. MP 803, a selection from the cross 7585-5B \times PI 162567, outyielded Century by about 15% in cooperative tests in 1974. A green-seeded pea introduction that yielded about 30% more than Triumph in preliminary tests was identified.

Diseases. Viability of *Ascochyta* spp. pathogenic on peas was assessed over 16 mo at several temperatures from -15 to 35°C . *A. pinodella* L.K. Jones remained viable at higher temperatures longer than did *A. pinodes* L.K. Jones or *A. pisi* Lib. All the species remained viable at -15°C . After 5 yr buried in soil, foliage infected by *A. pinodes* had decomposed to such an extent that it was impossible to recover the organism. In tests of 144 pea introductions for disease reaction to *A. pinodes*, only one line showed appreciably more resistance (18%) than Century. Mycological and pathological studies of *Ascochyta* isolates that were pathogenic to peas indicated that *A. pinodes* was the species present in Manitoba. The isolates that fitted into the *A. pinodella* category were more virulent on fababean epicotyl than those of *A. pinodes* or *A. pisi*.

Management. In a 3-yr study, Delwiche Scotch Green was sown on two dates and harvested five times at weekly intervals. Greenness of the seed cotyledons usually decreased with delay in harvest, whereas protein content did not change. Yield and seed size were decreased by delay in seeding date and by early harvest. Tests conducted for 5 yr on date of seeding involving Century, Trapper, and Delwiche Scotch Green showed that early seeding in May gave higher yields. Although protein content in late-seeded peas was high, total protein production per hectare was significantly higher in early seeded peas.

OILSEED CROPS

Flax

Breeding. The release of F.P. 597, an experimental line developed at Morden as a replacement for the rust-susceptible Redwood 65, is planned. In 2 yr of tests in Western Canada, F.P. 597 was very similar to Redwood 65 in all agronomic and quality characteristics, but had resistance to the new rust races 370 and 371. The rust resistance of F.P. 597 is derived from Raja, one of its parents.

C.I. 2776, an experimental line developed by the Agricultural Research Service of the USDA that will be licensed in the USA in 1975, was tested for the first time in the cooperative test. In comparison with Linott, this line was slightly later in maturity, lower in seed yield, equal in oil content, and superior in oil quality. C.I. 2776 is very well adapted to late seeding and has the same gene (L^6) for rust resistance as Linott.

Disease. In 1974, flax rust caused little damage to the susceptible and widely planted varieties Noralta and Redwood 65. Hot, dry weather in June and July largely arrested the development and spread of the rust pathogen. Whereas only light infections occurred in southern Manitoba, rust was common in the Dunsmore-Eston-Kindersley triangle in Saskatchewan, particularly on the variety Norland. Rust was, however, more widespread at the beginning of the crop year 1975 than at the beginning of 1974. Race 370 that attacks the N^1 resistance gene occurred again, but the new races 371 and 372 that have combined virulence to the L and N^1 genes predominated. These races of wider virulence are probably hybrid products from recombination and segregation involving races 300, 370, and others. When inoculated with race 371, many commercial seed lots of Linott imported from the USA contained 5.1–100% rust-susceptible plants. Registered and most Certified seed lots were of standard quality and contained not more than 2% rust-susceptible plants.

Management. Linott, Noralta, and Nored were grown for 3 yr at 100, 250, 400, 550, 700, 850, and 1000 plants/ m^2 with N added at 0, 67, and 134 kg/ha. In 1971, Linott flowered earlier than Noralta and Nored, was shorter, earlier maturing, and higher yielding. Linott also had a higher seed : straw

ratio, which it maintained at the high levels of N, whereas the other varieties declined sharply. The yields of Linott and Noralta increased at the four lowest plant densities (to 550 plants/m²), but Nored showed little response, possibly due to its more extensive tillering at the low plant densities. In 1972, applications of N had no significant effects, probably due to the shortage of soil moisture. Yields increased at the three lowest plant densities (to 400 plants/m²). In 1973, Linott lodged during an early storm but recovered, whereas Noralta and Nored lodged during a later storm and did not recover. Stage of maturity appeared to have been a critical factor. Lodging increased at increased plant densities and greatly reduced seed yields.

Quality. The amount of oil extracted from flax seed by pressure varied from 47% of the total oil in Redwing to 54% in Redwood 65. The moisture content of the seed had considerable effect on the amount of oil extracted, which varied from 48% in samples stored in cool seed storage to 70% in samples that had been oven-dried at 70°C.

Herbicide susceptibility. Stem protein was increased and leaf protein was decreased in six lines of flax treated with MCPA. Although the lines known to be susceptible appeared to have suffered a greater decrease in leaf protein after treatment, the results were too variable to measure differences between lines. In field tests, the content and composition of oil from weed-free flax treated with several common herbicides were modified by herbicide treatment. Under weed-free conditions, the yield of oil per hectare from seven varieties and lines was reduced by treatment with a combination of MCPA (estamine formulation) at 0.84 kg/ha and dalapon at 1.12 kg/ha.

Sunflowers

Breeding. Two new introductions from the USSR performed well in cooperative tests. Saliut was similar to Krasnodarets but showed a slightly higher seed yield and oil content. Woschod, which matured late, had the highest oil content, 45.8%, compared with 43.3% in Krasnodarets, and produced the highest oil yield in Western Canada. Several single-cross hybrids showed potential in increasing sunflower production. Two hybrids involving Morden male sterile lines and a French fertility restorer outyielded the control varieties by 20–30%. Two-thirds of

the 150 hybrids obtained from crosses of inbred lines on sterile Krasnodarets outyielded Krasnodarets, and the oil content in most of these was from 48 to 50%, compared with 45% in Krasnodarets. The maturity in 30–40% of these lines was similar to Krasnodarets.

Disease. Row spacing has been found to be a factor that can reduce yield losses caused by sclerotinia root rot. Seed yield was higher and disease infestation lower at a row spacing of 60 cm than at spacings of either 30 cm or 90 cm. Incidence of sclerotinia root rot in 5645 plants of unselected Peredovik averaged 32%, whereas 4888 plants of progenies from selections averaged 16%. The possibility of breeding for resistance to root rot appears encouraging.

Weed control. Two new dinitroaniline herbicides, fluchloralin (BAS 3921; BASF Canada Ltd.) and profluraline (CGA-10832; Ciba-Geigy Canada Ltd.), applied as pre-plant treatments at 1.4 kg/ha gave the same control as trifluralin at 1.12 kg/ha on a clay loam soil. Studies on weed competition indicated that, when sunflowers are grown with wide row spacings, the major portion of the competition can be attributed to the weeds growing between the rows in the first 4–6 wk after seeding.

VEGETABLE CROPS

Cucumbers

Breeding. Two gynoeious pickling-cucumber hybrids bred at Morden showed promise in once-over commercial harvest and in tests at various sites in Canada and the USA. They have been released as Earlimor and Alouette.

Two new radiation-induced seedling markers, yellow cotyledon, *yc-2*, and revolute cotyledon, *rc*, were shown to be monogenic, recessive mutations, which segregated independently. There was no evidence of linkage between *yc-2* and seven other plant characters.

Potatoes

Breeding. Two selections, F60075 and FS6222, which set tubers relatively early in the season, showed promise for earlier harvest of potatoes for chipping immediately after harvest. Also, these selections can be harvested for the early fresh market at the

same time as Warba and for processing much earlier than Norchip.

Several cultivars, selected because they make light-colored chips directly from storage at 4.4°C, have been intercrossed. Seedlings will be selected to produce a chipping cultivar that may be stored at temperatures below those at which the silver scurf disease proliferates.

Progeny from $4n \times 2n$ crosses involving *Solanum tuberosum* L. cultivars and diploids (*S. tuberosum* L. \times *S. phureja* Juz. & Buk. hybrids) have been intercrossed and backcrossed to *S. tuberosum* cultivars. The matings were mainly at the $4n$ level and fertility was reasonably good.

Quality. Firmness of french fry strips was increased by 56% for Norland and 51% for Netted Gem potatoes by holding them in hot water (60°C) for 1 h.

Sweet Corn

Breeding. Of 62 Morden hybrids selected in 1973, three for the fresh market that are as early as or earlier than North Star and six for processing that are earlier than NK51036, the standard hybrid, are being tested further. Of 155 new hybrids, 14 comparable to North Star and 23 comparable to or earlier than NK51036 are being evaluated further.

NEW CROPS

Carbohydrate Crops

Evaluation. Many variations in tuber morphology and inulin content were observed among new lines of Jerusalem artichoke, *Helianthus tuberosus* L. Preliminary analysis of tuber pulp after extraction of inulin indicated good protein quality and content (26.8–28.1%).

Management. Yields of tubers were increased when the size of seed pieces and plant spacings were increased. However, treatment with captan, application of high rates of trifluralin, and low fertility reduced yields when soil moisture was low. In cooperation with the Manitoba Department of Agriculture, conventional field equipment for potatoes was assessed and found satisfactory.

Protein Crops

Management. Highest yields were obtained with 15-cm row spacing, although plant height did not increase in mung beans, azuki

beans, or lentils grown at three locations. Seeding after the first week of June drastically reduced yields. Evidence was obtained that preplant-incorporated treatments with dinitroaniline herbicides are well tolerated by beans, lentils, and lathyrus.

Diseases. Lathyrus, lentils, and lupine accessions were diseased by soil-borne fungi. *Lupinus angustifolia* L. showed two wilt-type symptoms and the incidence varied with row spacing. *Rhizoctonia* was readily isolated from diseased lathyrus plants, whereas both *Rhizoctonia* and *Cylindrocarpum* were found on diseased lentil plants.

Essential Oils

Evaluation. Fennel, *Foeniculum vulgare* Mill.; sage, *Salvia officinalis* L.; summer savory, *Satureja hortensis* L.; basil, *Ocimum basilicum* L.; and coriander, *Coriandrum sativum* L., appear to have potential as essential oil plants for Western Canada.

Management. Pilot production of commercial dill carried out in cooperation with Manitoba Research Council and Manitoba departments of Agriculture, and Industry and Commerce was successful. Oil quality was excellent (30–42% Carvone) and yields up to 93.0 kg/ha were obtained. Trifluralin and certain experimental dinitroaniline compounds were tolerated by dill. Monarda, *Monarda fistulosa* L. var. *menthaefolia* (Graham), was readily propagated in mist chambers and grew well when transplanted into the field. Several experimental herbicides including the dinitroanilines and Hoe-23408 were tolerated by the crop.

ORNAMENTALS

Breeding

Three new hardy perennial cultivars have been described and named for release through the Canadian Ornamental Plant Foundation. *Chrysanthemum* 'Morden Everest' grows 3.0–3.9 dm high and 4.6–6.1 dm wide; profuse double white flowers, 7.5 cm in diam, bloom from mid-September. *Chrysanthemum* 'Morden Eldorado' grows 3.0–4.6 dm high and 4.0–5.1 dm wide; flowers are bright yellow, 7.5 cm in diam, and bloom from early September. *Physostegia* 'Morden Beauty' (a first-generation hybrid of *Physostegia virginiana* Benth. 'Summer Glow' \times *P. formosior* (Lunell) Rydb.) bears dark

green lustrous foliage and grows 7.6–12.2 dm high. The numerous inflated tubular flowers, borne through August, are violet with a lighter throat marked with dark veins. It has performed well under dry conditions and should also thrive in moist sites, where its parents grow naturally.

Discovery of self-compatible genotypes in *Chrysanthemum morifolium* Ramat. has enabled selfing of this usually outcrossing species. A preliminary assessment of inbreeding depression indicates greatly reduced seed germination, vigor, and flowering in both the first- and second-generation inbreds. Thus, alternate selfing and outcrossing appear essential to retain vigor during uniform line development in this hexaploid crop.

Five native rose species have been identified as sources of peonin, one of three anthocyanins associated with red flower color in roses. A new combination of the pigments peonin, cyanin, and pelargonin was found in 10 seedlings derived from native prairie rose, *Rosa arkansana* Porter, crossed with scarlet hybrid tea cultivars. Several new shades of flower now appear possible by recombining peonin with the cyanin and pelargonin of existing hybrid tea cultivars.

Promising selections from breeding programs that are in advanced tests include ornamental sunflowers, shade trees, roses, double-flowered hawthorns, late flowering lilacs, garden chrysanthemums, and hardy columnar aspen hybrids.

Arboretum and Evaluation

Restructuring of arboretum plantings neared completion with the preparation of a new planting block for conifers. A cumulative survival and hardiness report for 595 taxa grown by nine cooperators in the Prairie Regional Trial was completed and is available on request. The first shipment of shade trees was sent to the Parks Departments of Edmonton, Regina, and Winnipeg, the cooperators in the Prairie Regional Shade Tree Evaluation Program. This program includes 19 genera and 42 species, the largest groups consisting of *Fraxinus* (ash) and *Tilia* (basswood). Two cultivars, *Monarda* ‘Neepawa’ and *Syringa* ‘Miss Canada’, released in 1974 received Merit Awards from the Western Canadian Society for Horticulture.

Propagation

Japanese elm, *Ulmus japonica* (Rehd.) Sarg., a hardy introduction from northeast Asia, is similar in growth form to American elm, *U. americana* L., but differs in its reported resistance to Dutch elm disease. Superior selections of Japanese elm, which in the past have been graft incompatible with American elm, were successfully propagated using seedling rootstocks of Siberian elm, *U. pumila* L. Seedlings of *Tilia* × *flavescens* A. ‘Dropmore’, a hybrid of *T. americana* L. and *T. cordata* Mill., were vigorous, hardy, and nearly as uniform as seedlings of either parental species. Because seed of the hybrid cultivar germinated more readily than *T. americana*, and seedlings were more vigorous than *T. cordata*, they will be valuable as rootstocks for basswood selections.

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¹On transfer of work to the Agricultural University, Wageningen, Holland, August 1974 to August 1975.

INTRODUCTION

In 1974, the growing season at Winnipeg was not favorable for cereal trials and field experiments. A wet spring delayed seeding until the first week of June and a dry period followed, in which only 38 mm (1.5 inches) of rain fell from mid-June to mid-August.

Research on cereal root rot was discontinued and Dr. Mills was reassigned to collaborate as a seed mycologist in studies on the ecology of pests associated with the deterioration of cereals and oilseeds in storage. He will spend August 1974 to July 1975 visiting laboratories in Europe and working with seed mycologists at Wageningen, Holland, to prepare for his new responsibilities.

To improve quality screening services to plant breeders in Western Canada, a second cereal chemist was brought to the project. Dr. Kosmolak will be responsible mainly for service and research related to common and durum wheat.

Further information on the research summarized in this report can be obtained from Research Station, Research Branch, Agriculture Canada, 25 Dafoe Road, Winnipeg, Man. R3T 2M9.

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BREEDING, GENETICS, AND CYTOGENETICS

Common Wheat

Further progress was made with backcross programs in which Neepawa is used as a recurrent parent. One study, concerned with leaf rust resistance, involved the use of four donors: RL 5404, which contributed a gene from *Aegilops squarrosa* L. for resistance in the adult plant; Maria Escobar; Terenzio; and El Gaucho. Separate backcrossing programs were followed by crosses and double crosses in order to incorporate the four genes into a single derivative of Neepawa. The four-gene combination was achieved but the lines must be increased before any can be tested for yield. Several three-gene combinations were increased in the field and will be tested for yield in 1975. Because of adverse linkage, one or more of the available combinations will have serious deficiencies. Other Neepawa backcross derivatives that were increased in 1974 have greater stem rust resistance, awns, larger head size, or postharvest dormancy.

A study was completed on the genetics of leaf rust resistance in a group of cultivars. Trintecino has three genes for resistance: *Lr1*, *Lr14b*, and a gene that gives a 2+ infection type to a few races. A single gene was backcrossed into Thatcher from the cultivar El Gaucho. Monosomic analysis indicates that it is on chromosome 2D, but this must be verified. Rafaela has two genes

for leaf rust resistance: *Lr17*, located on chromosome 2A, and *Lr14b*. Two leaf-rust-resistant backcross lines, with Thatcher as the recurrent parent, were produced from the cultivar Terenzio; one has a gene that may be the same as an allele at the *Lr3* locus, and the other gives a rust reaction pattern similar to that of a Thatcher backcross line previously isolated, with resistance from the cultivar Lageadinho.

A group of wheat cultivars highly resistant to stem rust were genetically analyzed. In all of them resistance in the seedling stage could be attributed to known genes. Agent had a gene from *Agropyron elongatum* (Host) Beauv., *Sr9d*, and *Sr10*; ESP 518/9 had as many as seven genes, *Sr5*, *Sr6*, *Sr7a*, *Sr8*, *Sr9b*, *Sr17*, and a gene that gives a type-2 reaction found also in the cultivar Webster; Romany had *Sr5*, *Sr6*, *Sr7a*, *Sr9b*, and the Webster gene; Tama had *Sr6*, *Sr8*, and *Sr10*; and Bonny had *Sr6* and *Sr11*.

Good resistance to stem rust and leaf rust was backcrossed into Marquis from the tetraploid amphiploids *Aegilops speltoides* Tausch. \times *Triticum monococcum* L. and *A. speltoides* \times *T. aegilopoides* (Link) Bal. Throughout the transfer, which involved up to seven backcrosses to Marquis, a strong association was noted between stem rust resistance, leaf rust resistance in the adult plant, and the non-free threshing habit. The problem with this material has been to obtain resistant selections that are fully fertile,

meiotically stable, and free threshing. A few lines of this type have now been isolated.

Seedlings of two New Zealand wheat cultivars, Kopara and Arawa, were infected with two virulent races of leaf rust that were differentiated by their virulence on Pembina and Thatcher. When the cultivars were infected with isolate 20-68, 18% more pustules per unit area and 41% fewer spores per pustule occurred on Kopara than on Arawa. Similar, though statistically nonsignificant, differences were observed in the reaction to isolate 156-64: 6% more pustules per unit area and 20% fewer spores per pustule were found on Kopara than on Arawa. Although both cultivars were susceptible to both races, quantitative differences were observed in the degree of infection and in the amount of sporulation.

In a study of the relationship of several quality characteristics to hardness in two spring wheat crosses, it was found that hardness of wheat as measured by particle size index was related to flour yield, mixograph peak height, farinograph absorption, and, to a lesser extent, remix loaf volume.

Durum Wheat

The cultivar Macoun, developed jointly by the durum wheat breeding programs at Swift Current, Sask., and at Winnipeg, was licensed. It is comparable to Wascana in yield across Western Canada, has shorter, stronger straw, and is superior in test weight and quality.

A study of the cross Wascana \times Quilafen, segregating for semidwarf habit, showed very strong association of plant height with kernel shriveling. It was also determined that the semidwarf character was conditioned by one recessive gene, and that pubescent glumes were conditioned by one dominant gene.

Oats

Advanced generation lines, originating from Rodney and Harmon types crossed with strains that contained rust-resistance genes derived from *Avena sterilis* L., were bulked and will be tested for yield in 1975. In addition to very good rust resistance, the new crosses have some smut resistance derived from Markton and from *A. sterilis*.

In a test of 21 highly rust-resistant lines with promising protein content, several approached Hinoat in protein content. Although these lines have rather low yields they mature very early, and this character, as well as their superior rust resistance, should make them very attractive for late planting, particularly on the eastern prairies where rust is a hazard.

OT 195, a high yielding, stiff-strawed, medium-early, naked oat strain, yielded about 15% more than Vicar, our best naked oat cultivar, and closely approached the yield of groats of Random, our highest yielding common oat cultivar. Because of its strong straw, OT 195 should respond well to good management.

A new dwarf oat was obtained by irradiation of OT 184 with 1,150 rads of fast neutrons. This strain appears to have the yielding ability and kernel type of Harmon. The mutant is about 65% as tall as Harmon, it is very stiff strawed, and no chromosomal irregularities have been detected.

Barley

Several two-rowed lines with improved malting quality (fast modifying enzyme system and high extract values), resistance to stem rust and net blotch, and desirable kernel type performed reasonably well in yield trials. One of these lines will be advanced to the 1975 Co-operative Test, and others will be advanced to the eastern prairie regional trials. Earlier problems with deficiencies in kernel type, introduced through the use of certain parents as sources of enzymes and disease resistance, were overcome.

Three six-rowed lines selected for high test weight performed well in eastern prairie regional trials. Two of these, with test weights comparable to those of two-rowed entries, outyielded the five control cultivars and will be advanced to the Co-operative Test.

Progress was made in incorporating genes for high lysine content into hulled and hull-less lines of both two-rowed and six-rowed types. Progress was also made in improving the agronomic characteristics and yielding ability of hull-less two-rowed and six-rowed lines intended for use as high-energy feed barleys.

In both two-rowed and six-rowed material, crosses incorporating genes for resistance to the new races of loose smut now prevalent on

the prairies are in the second to fourth generation.

Techniques for screening barley hybrid populations for malting quality were further refined; autoanalyzer assays for amylase activities were improved; and a test for beta-glucan content and an index of malting and malt protease activities were developed.

CEREAL RUSTS

Stem Rust of Wheat

An analysis of results obtained over 10 yr by the Winnipeg formula method of race identification revealed that, in recent years, most changes in rust races caused an increase or decrease in virulence on a specific gene for host resistance. On single-gene differential cultivars, chronologically related differences in virulence between strains of standard rust race 15B-1L form an evolutionary series of single-step changes whereas differences in virulence between strains of standard race groups 11-32, 17-29, and 56-125 do not. Most changes were from avirulence to virulence, or vice versa, but on cultivars with resistance genes *Sr7a* and *Sr11* intermediate virulence occurred, which suggests that the strains underwent more than one kind of genetic change. There was no indication of an overall increase or decrease in the number of virulence genes present, although virulence against genes *Sr7a* and *Sr5* increased. Random changes in virulence on specific genes for host resistance seem to occur frequently, probably as a result of mutations. They permit the rust to overcome single-gene resistance but they are not very effective in overcoming complex resistance. The stability of complex resistance in North America suggests that other processes, capable of producing a wider range of variability, do not occur frequently in nature.

Leaf Rust of Wheat

The late planting of wheat in 1974 and the presence of considerable areas of leaf rust in the southern United States indicated that appreciable damage from leaf rust might occur in wheat. However, very dry conditions during the summer delayed rust development and only trace to light infections occurred on wheat in Manitoba and Saskatchewan. Preliminary results from the leaf rust race survey indicated a slightly increased level of virulence on wheats with alleles for resistance at

the *Lr2* locus. This may be a random shift or may reflect a change in the rust populations on Mexican wheats, in which gene *Lr2a* has been used during breeding.

Stem Rust of Oats

A major shift in race distribution was apparent from survey results after several years of relative stability. Several new races were identified that are virulent on oats with gene *pg13* and are distributed in both Eastern and Western Canada. Initial screening of the original collection of oats from North Africa and the Mediterranean basin to identify sources of stem rust resistance was completed.

Crown Rust of Oats

A new system of differentiating crown rust races was developed. The general level of resistance in the standard set of differential cultivars is high, and does not reflect the full range or various combinations of virulence genes in the crown rust population. The standard cultivars were replaced by selected lines of better known genetic composition, most of which contain single genes for resistance to crown rust. All known resistance genes of present or possible future interest in the breeding program were included.

In the 1974 survey there was a significant increase in the number of cultures virulent against *Pc40*, although this gene is not used in the Winnipeg breeding program. The two main resistance genes, *Pc38* and *Pc39*, which are used in the Winnipeg breeding program, have retained good resistance although a number of cultures have appeared that are moderately virulent against gene *Pc38*. The effectiveness of the other resistance genes remained unchanged.

Further observations were made on the role of buckthorn in the development of crown rust in Manitoba. Although climatic conditions in 1974 were unfavorable for rust development, heavy infections of oats occurred near buckthorn both in experimental areas and in farm fields. Oats near buckthorn became infected about 1 mo earlier than those infected by inoculum from external sources, and their yield was reduced.

Additional wild oat collections were initially screened for crown rust resistance. The more resistant lines of these and previously screened collections were carried through the second phase of screening; additional crown

rust races were used and environmental conditions were varied to assess resistance further. Several lines appeared to be excellent potential sources of resistance, and these are being phased into the crossing program to determine whether new genes can be isolated. Several lines also appeared to have temperature-sensitive or adult resistance, and genetic analysis of these has also started.

Molecular Biology of Rust Resistance

Recent investigations showed that ribonucleic acid (RNA) is directly involved in the resistant reaction of wheat to stem rust and that the active RNA shows specificity comparable to that of the whole host-parasite system. To determine whether the active RNA was produced by the host or the fungus, near-isogenic lines of the wheat cultivar Chinese Spring containing either gene *Sr6* for resistance or gene *sr6* for susceptibility were infected with race C17(56) containing gene *P6* for avirulence or with race C45(56A) containing gene *p6* for virulence. Separate extracts from infected wheat leaves, representing the four possible gene combinations, were prepared and tested for activity by bioassay. Active extracts were obtained from infected plants that represented the interactions of gene *Sr6* or *sr6* with *P6*, but not from infected plants that represented the interactions of *Sr6* or *sr6* with *p6*. These results showed that the genotype of the host was not important for production of the active RNA but that the gene for avirulence was essential. The active RNA thus appeared to be a product of the gene for avirulence.

In earlier experiments, active extracts could not be obtained from Chinese Spring wheat that contained gene *Sr5* for resistance, when it was infected with a race of stem rust that had gene *P5* for avirulence. The lack of activity was attributed to the limited fungal development characteristic of this gene interaction. If the genotype of the host is not important for production of the active RNA, it should be possible to obtain an active extract from genotypically susceptible wheat leaves infected with a race such as C24(17), avirulent with respect to gene *Sr5*. An active extract was obtained from this host-parasite complex, which supports the conclusion that the active RNA was produced by the avirulent pathogen. The extract was not active when tested against *Sr6* in the bioassay

system. This result was expected because race C24(17) is virulent with respect to *Sr6*, and it showed that the extract was specific in its interactions with genes. So were extracts from host-parasite complexes involving other genes for avirulence.

OTHER CEREAL DISEASES

Smuts

Haynaldia villosa Schur. and *Secale silvestre* Host, two new hosts, were found to be susceptible to loose smut of wheat, *Ustilago tritici* (Pers.) Rostr. The races of *U. tritici* virulent on species of *Aegilops*, *Agropyron*, and *Elymus* were determined. *Agropyron scabriglume* (Hark.) Par., *A. semicostatum* (Steud.) Nees ex Bois., *E. angustus* Trin., and *E. canadensis* L. were susceptible also to true loose smut of barley, *U. nuda* (Jens.) Rostr., four new host records. These species are the first known common hosts for the loose smuts of wheat and barley. One of the above species, *A. semicostatum*, was susceptible also to *U. avenae* (Pers.) Rostr., *U. kolleri* Wille, *U. nigra* Tapke, *U. hordei* (Pers.) Lagerh., and *U. bullata* Berk. in test inoculations. This grass species is thus a common host for the important *Ustilago* species from wheat, oats, and barley, as well as for the ubiquitous *U. bullata* from grasses.

A technique to perform intraspecific crosses in *U. nuda* was developed and applied to study the inheritance of buff spore color, and of virulence on the barley cultivar Warrior. The buff spore color of an albino strain was recessive to the brown color of the wild type. Virulence on Warrior was also recessive. This virulence and that on the cultivar Titan were transferred from a wild-type strain into the buff strain.

The relationship was determined between virulence on barley cultivars Lion and Plush and the genes *Uhv-1* and *Uhv-2* of covered smut, *U. hordei*. The virulence was caused by a single recessive gene, which was not linked to the other two genes. Combination of this gene with *Uhv-1* was required for virulence on Vantage but not for virulence on Hannchen, nor with *Uhv-2* for virulence on Excelsior, nor with *Uhv-1* and *Uhv-2* for virulence on Himalaya.

Tests of hybrids carrying *Un8* show that this gene will be of value in breeding for resistance to *U. nuda*. The use of cultivars Trebi, Valkie, and Compana is limited

because a biotype virulent on these sources of resistance is present in the area. More than 100 other lines of barley, mainly from Ethiopia, are being screened for resistance.

Foliage Diseases

Cultures of *Pyrenophora teres* (Died.) Drechs. that produced spot rather than net symptoms on inoculated plants were isolated from barley collected near Winnipeg. Spot-type symptoms were similar to those of spot blotch caused by *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur. The cultivars Herta and Fergus, previously reported to be moderately resistant, were susceptible to both types of isolates. At present, these two cultivars account for almost all the two-rowed barley and about half the total barley crop grown in Manitoba. The resistant lines CI 5791 and BT 201 retained their resistance to the isolate that produced typical net blotch but were less resistant to those that produced the spot-type symptom.

The range of symptom types produced by *C. sativus* on the leaves of 12 barley cultivars was examined and a system of classification into six symptom categories was developed. Betzes barley exhibited the most restricted symptom type, an irregularly shaped lesion with little or no necrosis, 7–10 days after inoculation. Symptom type and total leaf area infected were used to compare the cultural conditions that led to optimal disease development in this host-parasite system. A 24-h humidification period at 22°C and a post-inoculation temperature of 15, 22, or 30°C resulted in good symptom expression and differentiation. Betzes exhibited the most restricted lesion type under any of the cultural conditions used.

The production of spermatia and protoperithecia by cultures of *P. teres* was compared under various cultural conditions. Spermatia were produced only at 10 and 15°C on V8 or Sachs agar medium with dialyzing membranes added to the agar surfaces. Protoperithecia were formed at 10, 15, or 20°C on both growth media when dialysis membranes were incorporated.

Field surveys were conducted to determine the prevalence and distribution of leaf-spotting diseases of wheat in the three Prairie Provinces. Tan spot, causal agent *Pyrenophora trichostoma* (Fr.) Fckl., spot blotch, agent *C. sativus*, and yellow leaf blotch, agent *Septoria avenae* Frank f. sp. *triticea* T.

Johnson, were found in 63, 60, and 11% of affected fields. Their distribution was widespread in Manitoba and Saskatchewan, but only one field with plants infected with tan spot and yellow leaf blotch was found in Alberta. Incidence of foliar disease was fairly light throughout the prairies in 1974.

A set of cultural conditions that promote disease development and a system for classifying host resistance were developed for the wheat leaf pathogen *P. trichostoma*. Plants in the three- to four-leaf stage were dipped for 15 sec in inoculum suspensions consisting of mycelium fragments from 2-wk-old cultures of *P. trichostoma* grown on 10% V8 juice agar. After inoculation, samples were humidified for 6, 12, 24, and 48 h, and wheat cultivars were classified into reaction types according to symptom development and the percentage of leaf area infected after 7 days. Of the wheats tested, Glenlea was rated as very susceptible, and symptoms appeared after only 6 h humidification. None of the commonly grown cultivars tested were rated better than moderately susceptible.

Barley Stripe Mosaic

Barley stripe mosaic (BSM) was detected in 41, 20, and 20% of the fields of two-rowed barley surveyed in southern Alberta, southwestern Saskatchewan, and southeastern Manitoba. Disease was also detected in 10% of the fields of six-rowed barley surveyed in southern Alberta but was not observed elsewhere in this crop. At present, BSM is believed to be most common in southern Alberta, where the average proportion of affected plants in surveyed fields of two-rowed barley in 1974 was about 3%.

The virion length distributions of each of four strains of BSMV, designated C1, C2, C3, and C4 in order of increasing severity of symptoms in Black Hullless barley, were obtained from metal-shadowed, leaf-dip preparations before and after three successive transfers of each strain. Three main virion components with normal lengths of 108, 125, and 148 nm were recognized. All three virion components were consistently resolved in preparations of C4, but only the latter two components in preparations of C2 and C3; the 125-nm component was most common in all preparations of strains C2, C3, and C4. In preparations of C1, the 108-nm component was most common and, although all three components were resolved at first,

only the 108- and 148-nm ones were resolved after three successive transfers. The number, normal length, and ratio of virion components appear to be useful criteria for differentiating and characterizing BSMV strains.

Transmission of BSMV through seed of naturally infected wild oat plants was demonstrated. Of the seedlings grown from seed of seven of these plants, 22% were found to be infected. Manual inoculation tests were conducted to assess the susceptibility of wild oats to isolates of BSMV from both barley and wild oats. Strains C1, C2, C3, and C4 from barley each failed to infect wild oats, whereas an isolate of BSMV from wild oats infected about 30% of the inoculated wild oat plants. The latter isolate was readily transmitted from wild oats to barley but not from barley back to wild oats. Wild oats were more susceptible to the isolates of BSMV from wild oats than were four cultivars of commercial oats.

Barley Yellow Dwarf

A severe epidemic of barley yellow dwarf virus (BYDV) occurred in an area of about 9.5 million ha (37,000 sq mi) in southern Manitoba and southeastern Saskatchewan. Aphid populations on cereals involving *Rhopalosiphum padi* (Linnaeus), *R. maidis* (Fitch), *Macrosiphum avenae* (Fabricius), and *Schizaphis graminum* (Rondani) were exceptionally high. Thirty percent of *R. maidis*, 6% of *S. graminum*, and 1% of *R. padi* sampled in the field near Winnipeg transmitted BYDV to test plants. Three strains of BYDV, one specific to *R. maidis*, one to *R. padi*, and one nonspecific, were identified among the virus isolates from cereals and aphids. The mean proportion of diseased plants was 33% in 65 fields of barley examined, 9% in 38 fields of oats, and 4% in 26 fields of wheat. Estimates indicated a loss of 6% of the potential yield of oats, equivalent to 92,500 t (6 million bu). Losses in barley were probably higher and also appeared to be significant in wheat.

A study was completed on the effect of concentration of BYDV inoculum on the yield of wheat, oats, and barley. Each plant of these cereals was infested with 1, 20, or 100 individuals of *R. padi* carrying nonspecific isolate 6801 or of *R. maidis* carrying isolate 7005 specific to *R. maidis*. Yield reductions were large for oats with both isolates and for barley with isolate 6801,

moderate for barley with isolate 7005, and small for wheat with both isolates. For the three host-virus combinations where yield reductions were large, seed yield per plant decreased progressively as aphid numbers increased. These responses to the levels of infestation were supported by similar responses in several other characteristics measured.

Examination by electron microscope of oat leaves inoculated with BYDV revealed the presence of the following inclusions in phloem parenchyma, companion cells, and sieve elements: virus-like particles, slender filaments, small vesicles containing fibrils, and an amorphous material. Cells with inclusions, presumed to be infected cells, were detected as early as 2 days after inoculation. At 4 days, virus particles and filaments were observed in some mature sieve elements. Early in the infection of the cell, the nucleus became distorted and filaments resembling those associated with the virus particles in the cytoplasm appeared in the nucleoplasm and nuclear pores. At 6 and 11 days, inclusions were seen in almost all phloem cells. Passage of the virus particles and filaments from many of these cells into channels of translocation was suggested by the appearance of these inclusions in plasmodesmata and in adjacent sieve elements.

Blue Dwarf of Oats

The cause of low or erratic transmission of oat blue dwarf virus (OBDV) by individual leafhopper vectors was investigated in a series of tests in which the consistency of transmission to flax was used, because that species is a good indicator host. In these tests only about half the leafhoppers transmitted the virus. However, after the first transmission, presumably at the end of the preinfection period, most of the infective leafhoppers transmitted OBDV consistently for up to 20 days to every plant exposed to them. This showed that flax was not resistant to OBDV and that transmission was not inhibited by any vector-plant relationship. The consistency of transmission also suggested that the retention period of the virus by the vector was adequate and that the concentration and release of virus were sufficient to infect plants during the retention period. Nine cultivars each of wheat, oats, and barley were moderately resistant to or tolerant of OBDV. Wheat

and oats appeared to be more resistant than barley.

STORED PRODUCTS ENTOMOLOGY

Surveys

Surveys of stored grain in Manitoba were continued on farms selected at random. Of 190 farm structures, 41% were infested with one or more species of insects. Numbers of fungus beetles decreased from the previous year, possibly reflecting the drier conditions of 1974. Infestations were highest in the northern grain-growing areas of the province. Infestations in wheat, oats, and barley did not differ significantly.

Biology

Experiments on the energy budget of the granary weevil indicated that 60% (or 75 cal) of a wheat kernel is required by the weevil for development from egg to adult under optimum conditions. This contrasts with the performance of the granary weevil in 54-kg grain bulks, maintained at 30°C, where environmental factors did not allow the insect to infest every kernel; after 6 mo of infestation the grain showed an overall 18.5% weight loss, with pockets registering up to 43.6% loss. After 6 mo the lesser grain borer had caused an overall weight loss of 37.7% in the grain bulk with a maximum loss of 90.5% in some pockets. In contrast, the rusty grain beetle had caused an overall weight loss of 2.1% with a maximum of 3.3%.

Insect Resistance

A microdrop technique was used to measure resistance to malathion of 15 strains of the red flour beetle collected from various regions throughout Canada. A strain obtained from a cargo ship in Vancouver was 20 times more resistant than a standard laboratory strain. The resistance of a strain from Montreal was 9 times that of beetles representative of strains from the Prairie Provinces, where malathion is used less frequently than at port areas for control of storage pests.

Control

The rate of breakdown of malathion and bromophos on concrete surfaces that had various pH levels was determined by bioassay; the rusty grain beetle and the red flour beetle were exposed for 24-h periods. The rusty grain beetle was generally more susceptible than the red flour beetle to both insecticides. When applied to concrete with a pH of 7 or 8.5, the effectiveness of bromophos wettable powder (WP) persisted for 32 days against the rusty grain beetle but only for 4 days against the red flour beetle. Bromophos emulsifiable concentrate (EC) was less effective than the WP formulation and persisted for only 4 days against the rusty grain beetle. Application of malathion EC at 2.5 g/m² was superior to application at 1 g/m², but the effects lasted for only 2 days at pH 8.5 and 1 day at pH 10.0 when tested against the rusty grain beetle. Fresh concrete has a pH of about 11.5, whereas the concrete floors of farm granaries 3–5 yr old have a pH of about 8.5.

Rates of unassisted air movement in stored grain under laboratory and field conditions were determined with SF₆ used as a gaseous tracer. Downward, upward, and lateral air flow within the microclimate of the interstitial atmosphere was measured in wheat, barley, oats, peas, flax, mustard seed, and rapeseed stored in steel bins. As little as 0.1 pl of SF₆ could be detected by a gas chromatograph fitted with an NI63EC detector. Rates of air movement varied from 0.25 to 2.0 cm/min. Temperature gradients, invariably present under field conditions, influenced the air flow profile; it had previously been shown that they influenced dispersion and patterns of distribution and persistence of fumigant gases and fumigant residues in stored grain.

FIELD CROP INSECTS

Grasshopper Surveys

Surveys for grasshopper eggs in the fall of 1974 showed that in the south central and southwestern parts of the province both the areas infested and degree of severity had decreased and the largest and most heavily infested area was in the Red River valley and the area west to Rathwell. The dominant

species in 1974 was the two-striped grasshopper; the clearwinged grasshopper, the secondary species, increased considerably and was more widely distributed. The forecast of grasshopper infestations in Manitoba for 1975 indicated that the area infested would decrease by about 25%, but the degree of severity would increase in the Red River valley.

Sugar Beet Insects

Eight insecticides were applied at various rates and by several methods to control the sugarbeet root maggot. Granular applications of aldicarb, Counter (Cyanamid of Canada), and carbofuran were very effective in controlling the sugarbeet root maggot and also protected seedling stands from damage by flea beetles. Spray applications of leptophos and chlorpyrifos at 560.5 g/ha (8 oz/ac) effectively controlled redbacked cutworms.

Sunflower Insects

The effect of foliage damage by adults and larvae of the sunflower beetle on some components of yield of sunflowers was studied in field trials. In 1973, seed yield was 24.3% less from sunflowers that were severely defoliated by larvae of the sunflower beetle than from plants where insecticides were used to destroy the larvae and limit defoliation. The yield loss reflected reductions in both the number of filled seeds per head and the kernel weight. A further loss was a significant reduction in oil content of seed from defoliated plants, which was 1.7% lower than that of seed from plants with limited foliage damage. In similar tests in 1974, despite light defoliation because of a low larval population, seed yield of untreated plants was 8–10.5% less than that of plants sprayed with insecticides. Plants that suffered defoliation, particularly at the seedling stage, matured 7–10 days later than those that were protected from damage by sunflower beetles. A single spray application of carbofuran, phosmet, azinphos-methyl, or methidathion effectively controlled adults and larvae of the sunflower beetle.

INTEGRATED CONTROL OF INSECT PESTS

Damage Assessment

Fifth-instar larvae of the bertha armyworm caged over rape plants at densities of 20, 50, and 100 per cage (0.84 m²) until they pupated reduced yields of rapeseed by 4, 17, and 17%. Yield losses apparently resulted from the cutting of blooming shoots in younger plants and cutting of pods in older plants. Laboratory studies indicated that mature larvae showed no preference for feeding on pods rather than leaves.

Biology

Ten generations of bertha armyworms were reared continuously without diapause on artificial diets that incorporated 86 variations of composition or manufacture. A satisfactory schedule of diets and feeding was developed by which bertha armyworms can be reared in lots of up to 15,000 for experiments. The best diets produced 90% living pupae, of which 80% were visually perfect and 10% showed various degrees of pupal malformation. Pupal size and vigor and adult vigor and productivity were equal or superior to those of field-collected insects; adults that emerged from pupae with mild pupal malformation showed no loss of vigor or productivity. A wild strain collected from the field in 1974 and reared for three generations on diet did not differ significantly from the strain in culture for 10 generations.

Bertha armyworms reared on a defatted diet of Feed Wheat (H. V. Nootbaar & Co., Pasadena, Calif.) survived poorly (44% reached the adult stage) and only 38% of adults had perfect wings. However, 83% survived and 76% of these had perfect wings when linolenic acid was added to the diet at 1 mg/g dry weight. Further additions of linolenic acid or the addition of linseed oil did not improve this performance. The amount of fat stored as linolenic acid by the insect increased as the dietary level increased but it remained less than half the level stored by individuals reared on rape leaves.

Experiments showed that nondiapausing pupae of the bertha armyworm are so sensitive to cold temperatures that they are completely unable to survive winter in the prairies. At temperatures below freezing, -7 to -18°C, pupae froze and died rapidly. At temperatures above freezing +1 to +5°C,

mortality increased with exposure time, and occurred both during exposure and during subsequent incubation when adults attempted to emerge. Emerging adults were abnormal, few mated, and few mated females laid viable eggs. Even 10 days of exposure to $+5^{\circ}\text{C}$ reduced oviposition to 43% of normal. At temperatures above the zero level for development, $+9$ to $+15^{\circ}\text{C}$, pupae developed normally and adults emerged. From data on the time required for development at various temperatures, the zero level for development was estimated to be approximately $+5.5^{\circ}\text{C}$ for eggs, larvae, and pupae.

Certain cyclic nucleotides were found to enhance the effectiveness of suboptimal doses of the molting hormone, ecdysone, in the bertha armyworm. Other cyclic nucleotides blocked the action of ecdysone completely.

Studies to determine the egg-laying behavior of females of the red turnip beetle were conducted in field cages. Females copulated for the first time a few hours after emergence and repeated copulation many times thereafter. Some of the females laid eggs before the 8th day after emergence, but most of them started oviposition between the 8th and 12th day. Egg-laying reached a peak between 12 and 16 days after emergence in mated females and about 8 days later in virgins, and declined gradually in both groups during the remainder of the oviposition period. Although females often laid eggs on successive days, the average interval between consecutive ovipositions was about 2 days. Each virgin female laid on the average 236 eggs and each mated female 426 eggs. Oviposition seemed to be inhibited somewhat on days when the weather was cool and cloudy and it rained or snowed.

Sampling Techniques

Studies were started to determine the flight pattern of adult bertha armyworms and to compare efficiencies of traps for adults by releasing known numbers of moths. The battery-operated Manitoba black-light trap was as efficient as two versions of motorized light traps that use AC power and are thus restricted to locations with a power supply. A pheromone trap baited with virgin females was not efficient. Newly emerged adults flew

downwind, 70% within an angle of $\pm 45^{\circ}$ and 82% within $\pm 65^{\circ}$ of the wind direction. The numbers of insects caught in traps located 45.7 to 274.2 m (50 to 300 yd) from the release points diminished in proportion to the densities calculated for increasing distances from the release point. It was roughly estimated that a light trap has a probability of trapping an adult if it approaches to within 7 to 10 m (8 to 11 yd) of the trap.

Tests to develop practical methods for assessing field populations of flea beetles were conducted on 20 plots of rape, each divided into three subplots. Three sampling methods, visual counts, sweep nets, and the D-Vac vacuum net, were compared. The D-Vac, after suitable modifications, was 95–100% efficient in removing flea beetles from the area sampled and is used as a reference to calibrate the other two methods.

Parasites

Surveys and studies continued on hymenopterous and dipterous parasites of rape-seed pests in Western Canada. Emphasis was on evaluation of *Athrycia cinerea* (Coq.) and *Banchus* sp., the two main larval parasites of the bertha armyworm. Both species were found in association with bertha armyworms not only in numerous rape-growing areas of Manitoba but also at a number of sites in Saskatchewan and Alberta. Both parasites were fairly host-specific in rape fields; they emerged rarely from other lepidopterous species collected on rape. Laboratory studies showed that only one of the parasite species survived on each multiparasitized host, and neither was intrinsically superior to the other. The survivor in each instance was determined by the intensity and timing of their respective attacks on the host. Propagation procedures were improved for both *A. cinerea* and *Banchus* sp.: in particular, methods were developed for breaking diapause and, in *A. cinerea*, for preventing or inducing it. Tests showed that whereas fall cultivation of rape fields killed many bertha armyworm pupae, it did not affect survival of *Banchus* sp. in cocoons in the soil. Pupal parasitism of the bertha armyworm was recorded for the first time: the species, an ichneumonid, parasitizes freshly formed pupae in the soil. Methods for propagating this parasite were developed and preliminary information on its biology and life history were obtained.

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Soil fertility

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Cereal, oilseed, and special crop
evaluation

INTRODUCTION

The research program in 1974 continued to concentrate on the production and harvesting of cereal, oilseed, special, and forage crops and the efficiency of utilization of these crops by livestock.

In October the agreement covering the beef cow management project (Pathlow Research Project) was signed by the Ministers of Agriculture for Canada and Saskatchewan. Excellent fall weather allowed the construction of sufficient facilities before freeze-up to house 270 Hereford yearling heifers, purchased in December for this project. Two pasture management systems on 436 ha of provincial community pasture land, two types of winter accommodation, two basic wintering rations, and, eventually, two different crossbred cow herds will be compared.

The first phase of the animal research barn was completed early in 1975 and the first lambs were placed on test in February. This facility will permit individual feeding of 120 lambs as well as storage and handling of rations, processing of samples, performance of minor surgery, and isolation of sick animals.

Besides publishing *Research Highlights*, the staff, with the help of the Information Division, undertook the revision of the publication *Forage production and utilization in the aspen parklands of Western Canada*. Four separate publications covering forage production, pasture production, harvesting, and utilization of harvested forages were prepared and are available either from the Information Division or from the Research Station. Send requests to the Director, Research Station, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Forage Production

Management of the alfalfa leafcutter bee. The transfer of alfalfa leafcutter bees and cocoons from the incubator to field shelters should take place during warm sunny weather. If bee emergence does not coincide with favorable weather, it may be necessary to interrupt incubation. When cocoons that have been overwintered at 5°C are incubated at a constant temperature of 30°C, the first females appear after 21 days and continue to emerge for 9 consecutive days. To determine whether a prolonged interruption of the incubation period affects survival and rate of emergence of female bees, the temperature was reduced from 30°C to 18°C immediately after the first one or two males had emerged. The cocoons were held at 18°C for 3, 6, and 9 days before the incubation temperature was returned to 30°C. These treatments lengthened total incubation time by only 1, 2, and 3 days and reduced the emergence period of the females from 9 days to 7, 6, and 4 days, respectively. None of the treatments affected the survival rate or vigor of the bees.

Effect of herbicides on legume seed production. In 1974, asulam and dalapon were applied at 1.1 kg/ha to an established stand of sainfoin, *Onobrychis viciaefolia* Scop., 25 cm high to try to control volunteer grass (mainly *Poa* spp.) and rough cinquefoil. Dalapon suppressed the grass without affecting sainfoin growth, but it induced considerable flower head sterility and reduced seed yield to one-third of that of the control stand, which produced 160 kg/ha. Asulam suppressed both grass and cinquefoil, but also damaged the sainfoin. Seed yield was approximately one-third of that of the control stand.

Niclofen applied at rates between 0.5 and 2.0 kg/ha to a seedling stand of red clover, *Trifolium pratense* L., in 1973 caused some leaf necrosis but had no residual effect on clover seed yield, which was 270 kg/ha in 1974.

Effects of herbicides on yield and quality of alfalfa. An established stand of variegated alfalfa, *Medicago media* Pers., was treated with 2,4-DB at 0.5–2.0 kg/ha and with 2,4-D at 0.5–1.5 kg/ha in October 1973. Half of each plot was mowed to 7 cm of stubble; the other half was left with a regrowth of about

15 cm. In 1974, the control stand yielded 5990 kg/ha. Production from treated areas ranged from 4850 kg/ha on areas sprayed with 2,4-D at 1.5 kg/ha to 6290 kg/ha on areas sprayed with 2,4-DB at 0.5 kg/ha. The effect of 2,4-DB was not significant, but 2,4-D reduced production of dry matter (DM) below that of the control ($P < 0.01$). There was a significant linear trend to reduced yield as the amount of 2,4-D applied was increased. Percentages of digestible organic matter and ash were not affected significantly by herbicide applications. Mowing just before spraying had no effect, indicating that the alfalfa was dormant at the time.

Effect of wild oat herbicides on seedling grasses and legumes in the greenhouse. The wild oat herbicides benzoylethyl and asulam were applied at 1, 2, and 4 kg/ha to seedling forages and large-seeded legumes growing at several stages in the greenhouse. Barban was applied simultaneously at 0.4 kg/ha. Seedling damage was evaluated 30 days after treatment. Asulam had the following effects. Bromegrass, *Bromus inermis* Leyss., was very susceptible at all growth stages tested (up to the fourth leaf at time of spraying). Crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., was susceptible as a seedling but relatively tolerant when sprayed at the six-leaf stage of growth. Sweetclover (*Melilotus officinalis* (L.) Lam.), fababeans (*Vicia faba* L.), field peas (*Pisum sativum* L.), and lentils (*Lens culinaris* Medic.) were intermediate in reaction with significant damage at high rates of application. Alfalfa was tolerant. All species except field peas were tolerant of benzoylethyl. Peas were moderately tolerant of this herbicide. As expected from previous work, all species were tolerant of barban.

Forage Harvesting

Harvesting alfalfa for dehydration. Height of cutting was proved to be more important than date of cutting in maintaining productive stands of alfalfa for dehydration. When a cutting height of 15 cm was maintained, the stubble leaves provided sufficient photosynthate to support regrowth without depleting root reserves. Eight alfalfa cultivars were harvested at various dates in September to leave 15 cm and 3 cm of stubble. The average winterkill was 10.5% for alfalfa with 15 cm stubble compared with 27.5% for alfalfa cut 3 cm high. Although high-cut

alfalfa yielded less DM per hectare than low-cut alfalfa, it produced similar yields of protein per hectare. High-cut alfalfa also contained significantly more carotene and was lower in crude fiber than low-cut alfalfa.

Hay-drying tower. Further modifications were made to the tower in 1974. Four, rather than three, legs now support the roof, which is raised and lowered by one tractor-powered hydraulic winch. The wire mesh skirt was replaced by one made of plywood panels held vertically during filling operations and allowed to flare out during unloading so that the hay at the edges of the stack is pushed in toward the unloading mechanism. A concrete base of 1.2 m was constructed to accommodate the drying and unloading duct below hay level. This year unheated air was used for drying at a cost of 61¢/tonne, which contrasted with \$4.95/tonne for previous years when heated air was used.

Harvesting losses. Bromegrass-alfalfa was harvested at two moisture levels with each of three machines: at 25.7 and 22.4% moisture with the Hesston stacking wagon (Model 10), at 25.1 and 18.0% moisture with the Vermeer large round baler, and at 26.1 and 15.0% moisture with a conventional baler. Neither method of harvesting nor moisture level significantly influenced the amount harvested per hectare. Yields of 5269 and 5045 kg/ha were obtained when the hay was harvested with the John Deere and McKee stacking wagons, respectively.

Storing hay. Hay harvested in large, round bales showed remarkable resistance to weathering, provided the bales were stored on a well-drained area or were otherwise prevented from absorbing moisture from the ground. If not so protected, bales and twine sometimes rotted or froze to the ground. Round bales stored in contact with one another spoiled at the points of contact. When the tops of mechanically formed hay stacks were not well formed, precipitation penetrated the stacks and caused spoilage. The seriousness of the problem depended on the amount of rainfall.

Forage Utilization

Evaluation of forage-harvesting systems. For the second consecutive year, bromegrass-alfalfa was cut and allowed to wilt or cure in the field windrows. The material

was then stored as silage (S), which contained 65% moisture; as chopped hay, which was dried in a hay tower (C) and contained 40% moisture; as mechanically stacked, long hay (ST), which contained 27% moisture; and as baled hay (B), which contained 15% moisture. The amount of DM harvested annually in each of the four systems averaged 5010, 4742, 4726, and 4636 kg/ha, respectively, over the past 3 yr. Forage from each system was fed ad lib. to groups of heifer calves. Dry-rolled barley at 0.9 kg/head per day was also provided.

Differences in gain and feed efficiency between treatments were more pronounced in 1974 than during the first year. Heifers fed ration C gained 0.65 kg/day and required 9.9 kg DM/kg gain. Corresponding values for the other three treatments were: S, 0.60 and 8.9; B, 0.51 and 10.7; and ST, 0.36 and 16.2.

Digestible organic matter (DOM) at the time of harvest was lower in 1974 than in 1973 (55.5 vs. 61.5%). In both years DOM decreased an average of 3% between harvesting and feeding the forage.

For 1 ha of standing crop, the liveweight gain in kilograms was estimated to be 466 for S, 511 for C, 272 for ST, and 468 for B.

Effect of wilting and use of a preservative on the feeding value of oat silage. Chopped, direct-cut (28% DM), and wilted (37% DM) oats harvested at the early to mid-dough stage were ensiled in separate bunker silos. Each silo was partitioned, and one-half was filled with untreated silage, the other with silage treated with formic acid (0.33 kg/100 kg) during filling. The four silages were each fed, with and without two levels of grain, to groups of eight yearling Hereford steers for 86 days.

When added to the direct-cut silage, formic acid had no significant effect on rate of gain or feed efficiency but did increase DM recovery from 86% to 92%. When added to wilted silage, formic acid improved both liveweight gain and feed efficiency by 17%.

DOM in the wilted, untreated silage was lower than that in the treated silage (47.8 vs. 49.2%), probably because higher temperatures (37° vs. 31°C) developed during fermentation of the untreated silage.

Supplementing the silage with 1.36 or 2.7 kg of grain increased average daily gains from 0.28 kg (with no grain) to 0.60 and 0.76 kg, respectively.

Pasture Utilization

Effect of pasture management on performance of yearling steers. Four systems of managing yearling beef steers on rotationally grazed brome-grass-alfalfa pasture have been compared for seven grazing seasons.

In 1973 abundant rainfall produced an average yield of DM of 5747 kg/ha, which was higher than that for any previous year and well above the average 7-yr yield of 4106 kg/ha. Daily liveweight gains averaged 0.89 kg, compared with a 7-yr average of just over 1 kg/day. Two reasons for the lower daily gains are apparent. First, in previous years all steers had been implanted with diethylstilbestrol (DES). Because this product is no longer available, a progesterone-estradiol compound (Synovex S) was implanted in half of the animals on each treatment to test its effect. Implanting increased gain by 0.25 kg/day. Second, the unexpectedly large production of DM resulted in understocked pastures and advancing plant maturity, which adversely affected animal gains. Gains per hectare for the treatments were 336 kg (pasture and silage), 312 kg (put and take), 352 kg (pasture and oat silage), and 423 kg (pasture and rolled barley) compared with 7-yr averages of 282, 273, 373, and 436 kg, respectively.

One replicate of each of the "put and take" and "supplementary grain feeding" treatments will be grazed for several years to determine the productive life of the sward. Gains per hectare in 1974 were 293 and 386 kg, respectively.

Effect of fertilizer on brome-grass-alfalfa pasture. A brome-grass-alfalfa pasture established in 1966 was fertilized with N at 0, 45, 90, 135, and 179 kg/ha starting in 1970. From 1971 to 1973 each level of N was applied with and without P at 20 kg/ha. Average maximum yield was 5574 kg/ha when 179 kg N and 20 kg P per hectare were applied and cattle were fed rolled barley on pasture. On these pastures forage yields and P levels in the soil were greater than they were on pastures where no supplemental feeding was practiced. On average, the application of 20 kg P/ha increased forage yield of DM by 26% (4613 vs. 3649 kg/ha), and 179 kg N/ha increased yield by 55% (4798 vs. 3086 kg/ha).

When N was applied at 179 kg/ha, the residual response in 1974 was 25% (4066 vs. 3272 kg/ha). There was no residual response

to P on pastures where grain was fed but a residual response of 9% in yield was seen when no supplemental feeding was provided on pasture.

Ruminant Nutrition

Rations for wintering pregnant ewes. One lot of young ewes and one of mature ewes were divided into three groups and fed one of three rations: (1) sun-cured alfalfa pellets (51% digestible organic matter, DOM; 17% crude protein, CP) and wheat straw (34% DOM, 2.6% CP) with a grain supplement fed during late pregnancy; (2) long brome-grass-alfalfa hay (55% DOM, 15% CP) and wheat straw, with ground hay fed during late pregnancy; and (3) crested wheatgrass (55% DOM, 10% CP) with a grain supplement fed during late pregnancy. Initially, the pellets and hay (rations 1 and 2) were fed to provide 50–60% of requirements recommended by the National Research Council (NRC).

During early pregnancy, ewes fed crested wheatgrass consumed slightly less than NRC requirements for dietary energy (DE). However, during the final 2 wk of pregnancy, consumption declined markedly (ca. 50%). Ewes fed the alfalfa pellets or the brome-grass-alfalfa hay consumed very little straw (0.25 and 0.15 kg/day, respectively, for the mature ewes and 0.13 and 0.08 kg/day, respectively, for the young ewes). Some additional straw was consumed from the bedded area. Body weight changes in kilograms per day over 1 mo for ewes fed the alfalfa pellets and brome-grass-alfalfa hay, respectively, were 0.06 and –0.05 for the mature ewes and –0.15 and –0.03 for the young ewes. When the brome-grass-alfalfa hay was fed ad lib., consumption of DE rose to near the NRC level for early pregnancy. Ewes fed ground (½-in. screen) brome-grass-alfalfa during late pregnancy consumed sufficient DE to meet their requirements.

The test indicated that ewes fed the long brome-grass-alfalfa hay would not consume significant amounts of poor-quality wheat straw. The same pattern was observed for young ewes fed alfalfa pellets.

Utilization of feedlot manure. Manure from beef cattle fed high-grain rations was dehydrated and pelleted. Eight individually fed yearling wethers were fed one of the following pelleted rations: (1) 50% brome-grass-alfalfa hay and 50% barley, (2) 50%

dehydrated manure and 50% barley, and (3) 100% manure.

During the 38-day feeding period, wethers fed ration 1 ate 2.05 kg of DM daily, gained 0.27 kg, and required 7.53 kg of feed per kilogram of gain. The DM in the ration was 62.7% digestible. Ration 2 was not readily accepted during the 1st wk but was readily consumed thereafter. Wethers ate 1.72 kg/day, gained 0.15 kg/day, and required 11.45 kg per kilogram of gain; digestible DM was 51.7%. Sheep refused to eat the 100% manure pellets initially, but once accustomed to them ate large amounts. Average daily DM intake and gain over 51 days of feeding were 1.39 kg and –0.09 kg, respectively; digestible DM was 26.7%. For the last 23 days of the feeding period, intake averaged 2.05 kg/day and gain, –0.07 kg.

The results indicate that dried feedlot manure can be used in rations for ruminants.

CEREAL AND SPECIAL CROP PRODUCTION AND UTILIZATION

Variety Testing

Spring wheat. The advantages of early-maturing cultivars were evident this year. Unfavorable spring weather and early fall frosts combined to place later-maturing cultivars at a disadvantage.

The utility wheat cultivars Pitic 62 and Glenlea outyielded the hard red spring wheats Neepawa and Manitou by over 20% but weighed less per bushel. Glenlea outyielded Pitic 62 and Norquay except in one early-seeded trial where Pitic 62 produced the highest yield.

Wascana gave the highest yield of the durum cultivars tested, but its test weight was reduced. Hercules matured a week earlier than Wascana.

Winter wheat. Winter wheat seeded September 5 outyielded that seeded on August 8 by about 40% and matured 4 days later. Yields of the best winter wheat cultivars were slightly better than yields of the spring-seeded utility wheat cultivars. Winterkill was reduced by good snow cover.

Oats. OT618, developed at Melfort, outyielded Random, the highest-yielding licensed cultivar, by 2% in trials at four locations in northeastern Saskatchewan.

Trials in which oats were harvested for forage were conducted on a small plot and

on a field scale. In the field trials the two forage oat lines IH1863-4 and OA123-81 yielded over 9885 kg/ha, whereas Fraser yielded 7428 kg/ha. A durum wheat cultivar, Wakooma, included in the small plot trial, gave yields of DM nearly equal to those of OA123-81.

Production Management

Effect of barnyard manure on light-textured soil. The effects of manure and chemical fertilizer on soil classified as BL and SbLL have been compared at Parkside, Sask., for 37 yr. The manure was applied at 34 tonnes (wet basis) per hectare during the summerfallow year of a 5-yr grain-forage rotation. The fertilizer was applied at the recommended rate, based on current soil tests, for each crop in the rotation. The rotation was fallow, wheat, wheat, hay, and hay.

The average annual increases in yield as a result of applications of manure and chemical fertilizer, respectively, over an untreated control for each crop were: wheat on fallow, 638 and 174; wheat on stubble, 433 and 343; 1st-yr hay, 1224 and 1017; and 2nd-yr hay, 1241 and 920 kg/ha. In the last 6 yr, tests for N, measured as nitrate, in soil treated with manure showed an increase over the control of 0.5 and 1.0 ppm (surface 0–61 cm depth of soil) on the fallow and stubble land, respectively. Similar increases in P of 2.4 and 13.3 ppm (surface 0–15 cm depth of soil) were measured on the manured fallow and stubble, respectively. The chemical fertilizer had little effect on the nutrient status of the soil.

Chemical summerfallow. Using herbicides alone or in combination with tillage produced higher wheat yields and similar levels of soil moisture, N, and P, than those obtained when using tillage alone over the last 9 yr.

When one to three tillage operations were replaced by a herbicide treatment for weed control, the yield of wheat averaged 3616 kg/ha. When tillage alone was used, the yield averaged 3487 kg/ha. Corresponding values for nitrogen measured as nitrate (surface 0–61 cm depth of soil) were 13.6 and 11.8 ppm; for P (surface 0–15 cm depth of soil), 32 and 30 ppm; and for soil moisture (surface 0–1.2 cm depth of soil) 58 and 57%. The treatments were applied to the same

plots in a 2-yr rotation to evaluate accumulative effects. The chemicals required to control grassy weeds are too expensive to recommend on a farm scale. However, a combination of herbicides for broad-leaved weed control and tillage for grassy weed control is economical and often more effective in weed and soil erosion control.

Effect of wild oats on rapeseed yields. The yield of rapeseed was adversely affected by an infestation of 200 wild oats per square metre in both 1973 and 1974. Removal of the wild oats 7 days after emergence reduced rapeseed yield by an average of 639 kg/ha. Allowing the wild oats to remain in the crop until harvest reduced the yield of rapeseed by 1618 kg/ha.

Response of wheat to fertilizer applications. Manitou wheat grown as a second crop after fallow showed an average 3-yr response (1969–71) of 1310 kg/ha to an application of 134 kg N/ha and 20 kg P/ha. Because of insufficient P available in the soil in 1969 (11.9 kg/ha), the response to 45 kg N/ha was only 155 kg/ha. When 10 kg P/ha was added along with the N, the yield increased by 954 kg/ha.

Crop Utilization and Animal Nutrition

Evaluation of Pitic 62 wheat using growing-finishing boars, barrows, and gilts. Three diets of *Triticum aestivum* L. cv. Pitic 62, with 0%, 7.5%, and 15% field peas cv. Century, and a fourth standard barley – soybean meal diet were fed ad lib. or semirestricted to boar, barrow, and gilt pigs over the period from 27 to 91 kg liveweight. All diets were supplemented with the same levels of mineral-vitamin premix and contained 12.7, 14.0, 14.9, and 16.6% protein, respectively.

With either ad lib. or semirestricted feeding, live performance and carcass quality of pigs fed the wheat diets improved with addition of peas to the extent that the 15% pea diet was at least equal to the standard diet (720 g liveweight gain per day, 3.66 kg feed/kg gain, 3.21 cm average backfat, and 33.6 cm² loin eye area when pigs were fed ad lib.; 613 g, 3.61 kg, 3.02 cm, and 31.4 cm², respectively, when pigs were fed for 45 min twice daily).

When nutrition was adequate, barrows grew faster than gilts but were inferior to them in efficiency of feed conversion (EFC) and carcass quality; boars were superior to

barrows in EFC and carcass quality. However, boars and, to a lesser extent, gilts could not grow as well as barrows when the diet or feeding method limited nutrient intake. Boars produced meat similar in color and odor to that from barrows or gilts, but the dressing percentage for boars was approximately 4% lower than that for other pigs.

Evaluation of cereal cultivars. The barley cultivars Bonanza and Galt and the wheat cultivar Pitic 62 were grown in 1972 and 1973 at Melfort; Bonanza was also grown approximately 180 km NE of Melfort at Cut Beaver, Sask. The 2-yr average yields in kilograms per hectare at Melfort for the three cultivars were 4156, 4334, and 4088 for grain and 457, 520, and 540 for protein. Yields of the cultivar Bonanza (3209 kg grain, 351 kg protein) were lower at Cut Beaver, where the growing season was shorter, than at Melfort. Although the highest concentrations of most of the essential amino acids were found in Pitic 62, Galt barley supplied the most lysine (0.55%, 23.9 kg/ha).

Diets containing recommended levels of minerals and vitamins were formulated from each cultivar. In 1972 sufficient soybean meal (SBM) was included to provide a minimum of 14.5% total dietary protein and in 1973 a fixed 10% SBM was used in each diet. Evaluation of the feeds for both years was based on relative performance of pigs fed ad lib. from 23 to 91 kg liveweight. Performance on the 1972 Melfort crops increased with the dietary level of SBM and was

highest for Bonanza (12.5% SBM) and lowest for Pitic 62 (1% SBM). Although the Bonanza (grown at Cut Beaver) diet contained 15.5% SBM, pig performance was slightly inferior to that obtained with the Bonanza (grown at Melfort) diet. Only small differences were observed in the pigs fed diets from the 1973 crops. These results suggest that maximum production and utilization will be obtained by growing cultivars having the greatest potential yields and supplementing pig feeds formulated from these cultivars with adequate nutrients.

Evaluation of field peas and fababeans. The field pea cultivar Century and the fababean cultivar Ackerperle, grown separately and together (seeded in alternate rows) yielded, respectively, 3013, 2554, and 3019 kg seed/ha to produce 663, 664, and 724 kg protein/ha in 1973. Each crop, included as 23.5% of barley-based diets, was compared with SBM (10% of diet) as the sole source of supplementary protein for pigs fed ad lib. from 23 to 91 kg liveweight. The pea and bean-pea diets produced the fastest growth, 814 g/day; however, the bean diet was also superior to the control (780 vs. 735 g/day). Better efficiency of feed conversion was obtained with the pea, bean, and bean-pea diets (3.62, 3.67, and 3.71 kg feed/kg gain, respectively) than with the SBM diet (3.82); however, average carcass measurements were similar for all diet groups. Although peas contained less protein (22 vs. 26%) than beans, they tended to have slightly higher levels of essential amino acids per unit of protein.

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All-India Dryland Program

Weed science—agronomy

INTRODUCTION

This report outlines the work done in 1974 at the Research Station, Regina. The Station is the main center for weed control research in Canada. Three weed science programs are under way: biological control, in which insects and other organisms are used to control weeds; herbicide behavior in the environment, in which the fate and movement of herbicides in air, water, plants, and soil are researched and monitored; and weed investigations, in which the biology of weeds and methods of their control are studied.

The Station also increases and distributes Breeder seed and seed of new varieties of cereal, forage, and oilseed crops developed by the Branch.

We congratulate Dr. G. G. Bowes, who obtained his Ph.D. in ecology at the University of Guelph, and welcome Dr. A. E. Cessna, an organic chemist, who joined the staff to do research on the fate of herbicides in plants. We offer our best wishes to Mr. E. S. Molberg, who retired in 1974 after 36 years of valuable service developing soil erosion control measures, crop production practices, and many of our current weed control recommendations.

Detailed information on research results can be obtained from the scientists. The address of this establishment is Research Station, Research Branch, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. R. Hay
Director

BIOLOGICAL CONTROL

A survey of insects that feed on weeds in Canada was continued with emphasis on dock, prickly-pear, dandelion, absinth, and *Polygonum* spp. Several new species of insects and host records were found. Identification of the complex of insects already attacking unwanted plants is the first step toward the biological control of these weeds and influences the choice of imported agents to be used against them.

Several insect colonies were established in the laboratory to determine host specificity. The insects included the European moth *Cucullia verbasci* (L.), which feeds on mullein; two seed-head flies, *Tephritis dilacerata* Loew., which attacks the perennial sow-thistle, and *T. formosa* Loew., a sibling species, which feeds on the annual sow-thistle; and two moths from Argentina, *Cactoblastis doddi* Heinr. and *C. bucyrus* Dyar, which feed in the pads of prickly-pear. Host specificity tests on the nematode *Paranguina picridis* Kirj. showed that, contrary to reports in the literature, it was not specific to Russian knapweed but attacked plants in two tribes of thistles. Tests on the beetle *Cassida hemisphaerica* Hbst. for possible control of bladder campion were concluded and the culture was destroyed. Probably other insects exist that present less of a threat than does

this beetle to ornamentals related to bladder campion.

Several imported insects found to be host specific were released. The European moth *Chamaesphesia empiformis* (Esp.) was released for the control of leafy spurge in Saskatchewan, but it has not been recovered. The beetle *Longitarsus jacobaeae* Watr., which attacks tansy ragwort, was released in British Columbia. It was recovered for the first time at the site of the previous year's release. The gall fly *Urophora cardui* (L.) was released in Saskatchewan and British Columbia against Canada thistle. It failed to breed in British Columbia. The moth *Metzneria paucipunctella* Zell. was released in British Columbia on spotted knapweed and was recovered in small numbers. The root-crown weevil *Ceutorhynchus litura* (F.) increased on Canada thistle in Saskatchewan. At the site in Ontario where the insect was released in 1967, the density of the thistle declined for the fourth consecutive year, and in marginal parts of the stand the thistle has disappeared.

The number of galls produced on 100 heads of spotted knapweed by the gall fly *Urophora affinis* Frfld. increased from 7.8 to 74 at the release site at Chase, B.C. On diffuse knapweed, the number of galls per 100 heads increased from 12.3 to 39 at Pritchard, B.C. Each gall on diffuse knapweed displaces an average of 2.8 seeds, so

that approximately five galls per head are needed to stop seed formation. Another gall fly, *U. quadrifasciata* Mg., offers considerable promise because it increases and disperses more rapidly than *U. affinis*. It reached a peak population of 20 galls per 100 heads at Pritchard, B.C., in 1974.

The nodding thistle seed-head weevil *Rhinocyllus conicus* Fr. increased at Aylesbury, Sask., to a density of 2.1 weevils per head and reduced seed production by 63% at the release site. Distribution of the weevil by the public was encouraged in Saskatchewan, and 10,100 weevils were released in Quebec and 4500 in Manitoba.

The spurge hawkmoth *Hyles euphorbiae* (L.) had a larval density of 0.6/m² at Braeside, Ont. This density is less than 10% of that needed for defoliation; because the moth has remained at about this level since 1970, it appears to be a failure as a control agent.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Air monitoring of 2,4-D. The levels of total 2,4-D in the air at Regina did not exceed the detection limit in any of the samples collected in the 1974 spraying season. This improvement over previous years may be attributed to the unusual growing season during which spraying of crops was extended over a long period of time.

Droplet drift potential from ground sprayers. The drift potential of the low-volume (56 litres/ha, 5 gal/ac) TeeJet 650067 nozzles was lowered from 4–6% to 2–6% when the pressure was decreased from 275 to 172 kPa (40 to 25 psi), depending on the wind speed at the time of the trial. Thus, reducing the hydraulic pressure lowered the drift potential by about half, but only at the lower wind speeds. A somewhat similar but less pronounced trend was evident for the high-volume (112 litres/ha, 10 gal/ac) TeeJet 65015 nozzles.

However, when the volume sprayed was increased from 56 to 112 litres/ha (5 to 10 gal/ac), the drift potential of these nozzles decreased from 4–6% to 1–4% at 275 kPa (40 psi) and from 2–6% to 1–4% at 172 kPa (25 psi), again depending on the wind speed at the time of spray application.

At low wind speeds, the drift potential from the TK .75 nozzles was equal to that

from the high-volume 65015 nozzles; both nozzles performed better than the low-volume 650067 nozzles. At high wind speeds, their performance was as follows: TK .75 > 65015 > 650067.

Herbicide volatility. A closed air-flow system for determining relative volatilities of herbicides was developed. The rate of volatilization of technical *n*-butyl ester of 2,4-D increased with the increase in flow rate, and the increase was linear with time. A straight-line relationship between the volatilization rate and temperature also occurred when log rates were plotted against 1/T.

With the closed air-flow system, the relative volatilities of the formulated butyl esters (high volatile), the *iso*-octyl ester (low volatile), and the amine salts were about 440:33:1.

Persistence and degradation of residues in soils. Dichlobenil, triallate, trifluralin, dinitramine, and simazine were applied to small plots at three locations in the fall. The following spring, recoveries ranged from 20 to 70%. No 2,4-D or dicamba residues were found. None of these herbicides left any residues at depths below 5 cm in the soils studied.

In laboratory studies, no dicamba loss occurred at –5°C. However, over 80% of the labeled dicamba was dissipated from the silty clay soil in 8 days at temperatures above 15°C, whereas 14 days and temperatures above 20°C were required for similar losses from heavy clay and sandy loam soils.

A procedure was developed to extract dichlobenil, dinitramine, triallate, and trifluralin from soils, either alone or in combination, and to perform routine analyses by gas-liquid chromatography (GLC). The method detects residues down to 0.05 ppm.

Hydrolysis of a variety of phenoxy alkanolic esters to their corresponding acids was rapid and complete within 48 h in moist soils. In dry soils, hydrolysis was minimal and the esters could be recovered unchanged from soils after several days.

Availability and mobility in soils. Fifty-seven percent of trifluralin and 75% of triallate were desorbed from montmorillonite after six rinses with distilled water. However, successive rinses with water yielded only limited recoveries of both herbicides from peat moss, cellulose triacetate, and wheat

straw; only 10–20% for trifluralin and 12–28% for triallate after six rinses could be recovered.

The adsorptive behavior of three uracil herbicides, namely bromacil, terbacil, and lenacil, was determined in five soils. The Freundlich constants (k values) for three herbicides ranged from 0.4 to 7.4 for bromacil, 0.6 to 7.5 for terbacil, and 0.7 to 14.2 for lenacil. The Q values (micrograms adsorbed per gram of organic matter) for the three herbicides were 43, 48, and 81, respectively. The relative ease of desorption of bromacil from the soils was Asquith sandy loam > Regina heavy clay > Melfort loam.

Soil columns were used to conduct leaching experiments on five soil types to determine distribution coefficients of the three acid herbicides. The distribution coefficients ranged from 0 to 0.08 for dicamba, 0.04 to 0.49 for picloram, and 0.14 to 3.38 for 2,4-D for five soils with organic matter varying from 2 to 10%. These values were comparable to the corresponding Freundlich constants (k values). The order of relative mobility of the three herbicides was dicamba > picloram > 2,4-D.

Persistence and mobility in irrigation ditches. A 3-yr study on the movement and persistence of four soil sterilants (simazine, atrazine, monuron, and bromacil) in irrigation ditches was completed. The relative order of mobility of these herbicides was bromacil > monuron > atrazine > simazine, whereas the order of their persistence was reversed. In irrigation waters, the highest herbicide concentrations were in the water samples collected in the first ponding, decreasing by two- to five-fold in the second ponding. Thereafter, the herbicide concentrations in all successive water samples were minimal.

Residues and metabolism in plants. A new program on the residues and metabolism of herbicides in weed and crop plants was started. Initially, the emphasis will be on wild oat herbicides.

A GLC procedure to extract, clean up, and determine amounts of trifluralin in the roots, stems, leaves, pods, and seeds of rapeseed plants was developed. Recoveries from spiked plant material ranged from 75 to 85%.

WEED INVESTIGATIONS

Wild oats. WL-29761 (Shell Canada Ltd.), an analogue of benzoprop, was applied at 0.21, 0.42, and 0.84 kg/ha to wheat, barley, flax, and wild oats in the greenhouse at three growth stages of wild oats and at two different pressures. Wild oats were controlled at 0.42 kg/ha with no apparent damage to wheat. Flax injury was evident throughout. Results with WL-29761 were considered superior to those obtained with benzoprop. The latter is currently recommended for the postemergence control of wild oats in wheat.

In field trials, control of wild oats with WL-29761 at 0.63 kg/ha in the three-leaf stage and at 0.84 kg/ha in the five-leaf stage was superior to that with benzoprop at 1.40 kg/ha.

HOE 23408 (Hoescht Canada Ltd.) was applied at 0.84, 1.12, and 1.40 kg/ha to Neepawa wheat, Bonanza barley, wild oats, and green foxtail in the greenhouse when the wild oats were in the two- and four-leaf stage. Wild oats in the two-leaf stage were controlled by all rates. Results were less satisfactory at the four-leaf stage. The wheat and barley appeared to be tolerant when the chemical was applied to the crop at the three- to five-leaf stage. Green foxtail was controlled with HOE 23408 at 0.84 kg/ha when the chemical was applied at the early three- and five-leaf stage. It appears that green foxtail can be selectively controlled by lower rates and at later stages than wild oats.

In field trials, HOE 23408 was tested at 0.84, 1.12, 1.40, and 1.68 kg/ha. Wild oat control increased by 50% when the rate was increased from 1.12 to 1.40 kg/ha, which indicates that the optimum rate for HOE 23408 is 1.40 kg/ha.

Control was also increased by increasing the pressure from 2 to 3 kg/cm² (30 to 45 psi) and tilting the nozzles 45° forward.

In the greenhouse, mixtures of molinate and propanil (1:1 and 2:1) were applied at 3.36, 5.04, and 6.72 kg/ha when green foxtail was in the three- to four-leaf and the six- to seven-leaf stage, wheat was in the three-leaf stage, and barley in the four- to five-leaf stage. Results with wild oats were unsatisfactory. Green foxtail was controlled by 73–100% when the 1:1 formulation was applied at the early stage, but control was less satisfactory with the 2:1 formulation. Some damage was evident in both crops

where the 1:1 formulation was applied at the later stage.

When compared in the same field trial, triallate (1.40 kg/ha), barban (0.35 kg/ha), HOE 23408 (1.40 kg/ha), and WL-29761 (0.84 kg/ha) controlled wild oats satisfactorily. Control was unsatisfactory with ben-zoprop at 1.40 kg/ha and with mixtures of AC 84777 (Cyanamid of Canada Ltd.) at 0.42 kg/ha and barban at 0.35 kg/ha and of molinate and propanil (2:1) at 4.48 kg/ha.

Rodney oat plants, produced from seed that had been treated with 1,8-naphthalic-anhydride (Protect; Stauffer Chemical Co.) at 0.25 and 0.5% by weight, were protected from serious injury when sprayed at the two-leaf stage with barban at 0.28 kg/ha. Damage was observed at the 0.42-kg/ha rate.

Persistence of weed seeds. In longevity studies, the viability of green foxtail seed at depths of 1.0, 2.5, 5, 10, and 15 cm in a sandy loam soil averaged 4.2, 5.4, 2.2, 17.6, and 30.8%, respectively, after burial for 7 yr. After burial for 8 yr, the viability of another population at depths of 1.0, 2.5, 5.0, 7.5, and 10 cm averaged < 1, 6, 4, 8.6, and 4.6%, respectively. Green foxtail seeds retained their viability in arable soil for at least 2 yr longer than was previously reported.

With foxtail barley, over 50% of the seeds on the soil surface were alive after 2 yr. From 6 to 13% were viable at depths ranging from 1 to 10 cm in Regina heavy clay soil. Less than 1.4% of the seeds were dormant at this time.

Canada thistle. A detailed field study to determine the efficacy of glyphosate relative to 2,4-D and dicamba plus 2,4-D (1:3) was started on fallow in 1972, seeded to wheat in 1973, and fallowed in 1974. Roots were removed from an area 0.75 m² to a depth of 1.2 m in the fall of 1973. In the checks, 11, 27, 41, and 22% of the root weight was found at depths of 0.3, 0.6, 0.9, and 1.2 m respectively; 67% of the roots were 3–6 mm in diameter. The herbicide 2,4-D at 1.12 kg/ha, dicamba and 2,4-D at 1.12 kg/ha, and glyphosate at 1.68 kg/ha decreased the root weight by 46, 35, and 74%, and the regenerative capacity of the root by 74, 40, and 94%, respectively. In 1974 top growth was controlled 63.1, 2.2, and 99.8%, respectively.

One year after a fall application of glyphosate at 1.68 kg/ha, top growth of Canada thistle was controlled 95% and the yield of wheat was increased by 22% or 282 kg/ha.

Nitrogen effects on Canada thistle. Seedlings of Canada thistle were grown in sand culture with a controlled mineral nutrient supply. Seedlings in the cotyledon stage were extremely susceptible to injury by high salt concentrations, and it was necessary to use a 10 times dilution of Hoaglands solution for successful establishment. Increasing the N supply from 5.25 to 420 ppm greatly increased the growth of the shoot and also promoted the growth of the buds on the root, many of which were induced to develop into leafy shoots.

Nitrogen at 210 ppm caused severe leaf necrosis and inhibition of shoot growth, when supplied as NO₃, but no deleterious effects were observed when some nitrogen in the form of NH₄ (NH₄-N) was provided. The number and dry weight of the axillary shoots and the number of visible root buds were significantly greater with NH₄-N than with NO₃-N at 210 ppm.

In another study, seedlings were supplied with NH₄-N at concentrations ranging from 5.25 to 420 ppm. The dry weight of the shoots increased as the nitrogen was raised to 210 ppm; further increases in nitrogen decreased shoot growth. The roots were cleared in lactic acid, and buds that were initiated, but not emerged, from the root were counted. The total number of root buds initiated decreased as the nitrogen supply was raised but the growth of the root buds was significantly increased. The roots also branched more frequently with increasing nitrogen.

Nutritional control of root-bud growth has an obvious significance in relation to herbicide treatments. In leafy spurge, nitrogen produced similar stimulation of bud growth and increased the translocation of ¹⁴C-labeled 2,4-D out of the treated leaf and into the stems, roots, and root buds. A 10-fold increase in 2,4-D was found in the root buds.

Range weeds. Glyphosate applied on rangeland at 2.2 kg/ha in band widths varying between 5 and 40 cm reduced the competition from the resident vegetation and permitted the establishment of alfalfa, sainfoin, and milkvetch. Because the spring of 1974 was wetter than normal, these treatments will have to be repeated under drier conditions. In other tests the yield of forage was not increased when weeds were controlled after 2,4-D, 2,4-D plus dicamba, or 2,4-D plus picloram was applied. When 34 kg/ha of

both nitrogen and phosphorus were added to any of the treated or untreated plots, the forage yield was almost doubled.

In an ecological study conducted during 1973 and 1974 on improved rangeland, less alfalfa grew directly under aspen poplar (*Populus tremuloides* Michx.) and prickly rose (*Rosa acicularis* Lindl.) than between these plants. No chemical treatment is available for selective control of prickly rose when alfalfa is present on rangeland.

Growth analyses of weeds. Experiments were conducted on dormancy of buds on quack grass rhizomes both in the field and under growth chamber conditions. Dormant buds were induced to grow by maintaining the rhizomes in a constantly moist environment. Therefore, the degree of water stress seems to play an important role in the control of bud activity.

The level of asparagine in quack grass rhizomes was approximately 10 times greater than that of any other amino acid but declined significantly when bud growth was induced. This suggests that asparagine is the main storage form of soluble N in the rhizomes and may also play a major role in N translocation. Amino-acid concentration decreased markedly from the apex to the base of the rhizome. This decrease was correlated with a gradient of decreasing bud activity, and its steepness was inversely related to the external N supply.

In a study of the mechanism of root-bud inhibition in leafy spurge, plants were grown at a high N level. When the parent shoot was removed, a marked increase in the water content of the buds occurred within 24 h. The shoot also continued to exert a significant degree of root-bud inhibition after all the apical and lateral meristems had been

removed. These results support the hypothesis that when N is nonlimiting, inhibition of root-bud growth is due mainly to internal competition for a limited water supply.

SEED SECTION

A 0.9-ha (2.2-ac) increase of a new rust-resistant strain of flax, FP597, was made in California during the winter of 1973-74. The seed was returned to Canada in time to make a further increase on 41 ha (102 ac) for distribution to seed growers and the seed trade. Material from 30 plant breeders was increased on the 5-ha (12-ac) winter nursery in the Imperial Valley of California. Seed harvested in this program was returned to Canada in time for planting. In New Zealand 0.4 ha (1 ac) of mustard, *B. hirta* cv. B.H.1245, was increased and 907 kg (2000 lb) of the returned seed was released to two crushing companies for further increase under contract.

In California 10 ha (25 ac) of a new leaf-rust-resistant strain of spring wheat, C.T.440, was seeded in October 1974. Seed from this increase will be returned to Canada and further increased under contract before release. Four new cultivars, Macoun durum wheat, Hudson oats, Mancan buckwheat, and Canuck hard red spring wheat, were distributed to seed growers and members of the seed trade across Canada. The Breeder seed maintenance program continued to expand. A total of 5980 kg (13,289 lb), which comprised 376 lots of 39 cereal and oilseed cultivars, were distributed to Canadian seed growers. In 1973, 4023 kg (8942 lb) of experimental seed of 61 different cultivars were sent out to fill 154 requests from Canada and eight foreign countries. This seed was for experimental or testing purposes and was not intended to be multiplied.

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¹On transfer of work at Vollebakk, Norway, September 1, 1974 to September 30, 1975.

INTRODUCTION

The Research Station, located on the Saskatoon campus of the University of Saskatchewan, conducts a comprehensive research program on development and production of crops and protection of animals. Included are the breeding of oilseeds, cereals, grasses, and legumes; ecology and control of some of the most important plant insect pests, plant diseases, and weeds; and the ecology and control of black flies and mosquitoes affecting animals and humans. Research is carried out on the epidemiology of western encephalitis, the histophysiology and nutrition of insects, the fertility and management of soils, pesticide residues in crops and soils, and methods of application of pesticides.

The Station works closely in a number of areas with many departments of the University of Saskatchewan and the Prairie Regional Laboratory of the National Research Council.

Accomplishments in selected subjects are summarized in this report. The mailing address of this establishment is Research Station, Agriculture Canada, University Campus, Saskatoon, Sask. S7N 0X2.

J. E. R. Greenshields
Director

CROPS

Oilseeds

Rapeseed breeding. In 1974, low-erucic, low-glucosinolate strains of *Brassica campestris* L. with partly yellow seed were widely evaluated in cooperative rapeseed tests. Quality characteristics, particularly oil content, of these strains were excellent. Oil content ranged from 0.8 to 1.5% higher than that of the control cultivar Echo. Further evaluations will be carried out with Saskatchewan-grown seed to reassess seed yield potential, because germination and stand establishment were poor in 1974 when tests were conducted with small, weak seed produced in the California winter nursery.

Resistance to white rust, *Albugo cruciferarum* S.F. Gray, was identified in wild *B. campestris* strains from Central and South America, and it is being incorporated into low-erucic, low-glucosinolate genotypes. Selections are now being made within early-generation segregating populations.

In preliminary field trials, several low-erucic, low-glucosinolate strains of *B. napus* L. were superior to the low-glucosinolate cultivar Tower in seed yield and oil content, and a few strains also exceeded the highest-yielding cultivar Midas in these characteristics.

Improved quality of yellow rapeseed. The chemical and morphological characteristics of the embryos and seed coats of F_2 populations segregating yellow- and brown-seeded

rapeseed were examined. On the average the yellow-seeded rapeseed contained 2% more oil, 1% more protein, and 4.4% less fiber than brown-seeded segregates. These differences were found to result from yellow seed having a thinner seed coat and a higher oil and protein content in the tissue. Results indicated that breeding for yellow seed may significantly reduce fiber content without sacrificing other agronomic characteristics such as yield or oil and protein contents.

In yellow and brown seed the seed coats contained appreciable proportions of the total seed oil (2-4%) and total protein (7-11%). Although dehulling would result in a more desirable meal with less fiber, it is doubtful whether the practice could economically be justified unless the hulls were further processed and used.

Independent inheritance of linoleic and linolenic acids in rapeseed oil. Study of selections for altered linoleic acid in the seed oil of rapeseed showed that the proportion of linolenic acid can be raised or lowered by breeding without affecting the total amount of oil formed. There was evidence that the amount of linolenic acid has been altered without a change in the amount of linoleic acid; thus, lowering the undesirable linolenic acid content through plant breeding may not necessarily result in a reduction of the desirable linoleic acid.

New test for glucosinolates in seed. A rapid and simple method for quantitative analysis of glucosinolates was developed; it uses a

commercially available test paper that reacts semiquantitatively and specifically to glucose. Glucose is released from hydrolysis of the glucosinolates by the endogenous myrosinase in aqueous extracts of rapeseed, and is measured after interfering substances have been removed with charcoal. The stability of the reagents and the simplicity, sensitivity, and speed (less than 5 min) of the test suggest that it could be used at farm delivery points and throughout the Canadian transportation and marketing system to identify seed of low-glucosinolate cultivars.

Interspecific hybridization. Selection in advanced generations of an interspecific cross of *B. napus* × *B. campestris* resulted in *B. napus* lines with high oil content, good yielding ability, earliness, and low contents of erucic acid and glucosinolates. Significant transgressive segregation for earliness, oil content, and yield in these lines confirms that interspecific gene transfer is a successful and promising breeding technique for *B. napus*.

Haploids. Studies on frequencies of spontaneous haploids in Canadian cultivars of *B. napus* indicated that selection can increase haploid frequencies more than 10-fold in a single generation. Progenies of plants selected from lines with high, medium, and low frequency of haploids generally remained in the same frequency classes, which suggests that the tendency for haploid production is highly heritable. Recent data indicate that spontaneous haploid frequencies significantly greater than 5% may be difficult to attain.

Crop losses because of wild oats in rapeseed. The advantage of early removal of wild oats from rapeseed was clearly established. Yields of rapeseed grown with a wild oat population of 200 plants/m² (per 1,550 sq in.) were compared with a yield of 1565 kg/ha (1,396 lb/ac) from a weed-free crop. When wild oats were removed 7 days after emergence, the yield loss was 8%; with removal at 21 days after emergence the loss was 22%; with removal at 40 days it was 61%; and with removal at maturity the loss was 69%. Tests also showed that a population of 10 plants/m² reduced yield by 18%, 100 plants/m² reduced it by 56%, and 300 plants/m² reduced it by 68%. This evidence emphasized the need to remove even light infestations at an early stage of development.

Weed control in rapeseed. Stinkweed, *Thlaspi arvense* L., has been one of the most

difficult weeds to control selectively in rapeseed or mustard. A new product, FMC 25213 (FMC of Canada Ltd.), applied preemergence to *B. campestris* and *B. napus* cultivars Torch and Midas, resulted in 80 to 85% control of stinkweed as well as other broad-leaved weeds. The rapeseed was fairly tolerant of the treatment. A second experimental product, 73-A176 (Allied Chemical Services Ltd.), applied as a postemergence treatment, controlled weeds as effectively as FMC 25213, but *B. campestris* was more susceptible to injury by it than *B. napus*.

Sunflower breeding and management. Early sunflower strains were identified that flowered 3 to 7 days earlier than the cultivar Krasnodarets and possessed fair stem strength, high oil content, and low hull content. Drifting of the herbicide 2,4-D caused damage in several commercial fields. Single-plant selection for tolerance for 2,4-D drift was effective, which indicates the feasibility of breeding cultivars that tolerate 2,4-D. The content of chlorogenic acid (CGA), the major phenolic acid in sunflower flour, was shown to be influenced by seeding date and stage of development of the kernel; early high-oil strains with 1% CGA, about one-half the normal level, were identified. The heads and stalks of the sunflower were shown to be desirable sources of water- and oxalate-soluble pectin; the yield and quality of the pectin were influenced by the stage of development of the plant.

"Sunfallow," the practice of seeding sunflowers in single or double rows spaced 3.7 m (12 ft) or more apart on cereal stubble intended for summerfallow, gave a substantial financial return in the summerfallow year.

Weed control in sunflowers. The problems of weeds in sunflower production are similar to those in production of rapeseed; however, tolerance for herbicides differs to some extent. A mixture of linuron and chloramben (1:3.3), applied as a preplant-incorporated treatment at 4.48 kg/ha (4.00 lb/ac), provided excellent control of weeds, including stinkweed. Crop tolerance was excellent. Two herbicides, RH2915 (Rohm & Haas Canada Ltd.) and oxadiazon (May & Baker), applied preemergence to the crop and weeds at 1.12 kg/ha (1.00 lb/ac) also gave good weed control and crop tolerance. Application of each of the three products resulted in yields equivalent to those from hand-weeded plots,

and weed control in each case was 80% or higher.

Legumes

A reliable assay for dicoumarol in sweetclover hay was developed in response to requests from feed analysis laboratories in Saskatchewan and Alberta.

Breeding for nonbloating alfalfa. The main objective in the alfalfa breeding program is the development of a nonbloating variety by reduction of the total soluble proteins (TSP) in the plant. High variability in TSP contents of individual plants suggests marked environmental influences and the need for well-replicated progeny tests. Lines with low and high levels of TSP are being selected concurrently to measure the success of the selection program. A high TSP alfalfa also may serve a future demand for alfalfa as a protein source. Preliminary data indicate that low TSP levels will not necessarily cause reductions in levels of total protein.

A second approach to developing a non-bloating alfalfa is to raise levels of palatable condensed tannins. The possibilities of using mutagenic agents, hybridization, and haploid cell fusion are being investigated.

A feeding trial to study bloat incidence is under way at the Research Station at Kamloops, B.C. Threshold levels of soluble protein at which bloat occurs as well as concentrations of other selected protein constituents are being determined.

Legume biochemistry. An improved procedure was developed for the extraction of soluble proteins. Samples, instead of being freeze-ground in liquid nitrogen, are freeze-dried and then ground. When protein fractions were analyzed by polyacrylamide gel electrophoresis, problems of poor resolution and background staining were encountered. However, good resolution was obtained when samples were desalted by dialysis or Sephadex G-25 chromatography and when electrophoresis was performed in sodium dodecyl sulfate. Electrophoretic properties of alfalfa leaf proteins were described and the proteins that contained bound lipids were identified.

Bate-Smith's astringency test for tannins was modified to give greater reproducibility. Also, Burns' vanillin-HCl screening test for condensed tannins was modified to avoid a false positive reading when alfalfa and other legumes were tested. No condensed tannins

were detected in the vegetative portions of 25 annual *Medicago* spp. and 25 *Trigonella* spp. Three *Trifolium* spp. contained condensed tannins.

Grasses

Recurrent mass selection in intermediate wheatgrass. Five cycles of recurrent mass selection of intermediate wheatgrass resulted in a 76% gain in seed yields. Gain per cycle was 9% when open-pollination seed was used to form the next generation, and 18% when selected plants were intercrossed to form the basis of the next generation.

Brome grass seed midge. The brome grass seed midge, *Contarinia bromicola* (Marik. & Agafonova), caused serious losses to seed growers in 1973 and lesser damage in 1974. Preliminary attempts to control damage by burning residues and by use of insecticides were not successful. Adults of the midge were present from June 17 to July 11 and numbers reached two to four per sweep at flowering time, July 5 to 8. Further attempts at control with insecticides will cover a longer period.

Heterosis in crested wheatgrass after strain interpollination. Moderate heterosis was obtained from natural interpollination of four tetraploid strains of crested wheatgrass in paired combinations. The average forage yield of 12 such "crosses" was 6.34 tonnes (t)/ha (2.83 tons/ac), the average of six seed blends 6.12 t/ha (2.73 tons/ac), and the average of pure strains 6.19 t/ha (2.76 tons/ac). The highest-yielding cross was of the cultivars Summit and Nordan, with a yield of 6.61 t/ha (2.95 tons/ac). Close scrutiny of plant type for this combination indicated 25% hybridization.

Irrigated pasture mixtures. A winter-hardy white clover from the Research Station at Melfort, Sask., was grown in combination with various grasses in 1971-74 and clipped two to three times per season to simulate pasturing. Highest yields of dry matter from grass-clover mixtures, over the period 1972-74, were obtained from Climax timothy, 5.47 t/ha (2.44 tons/ac); intermediate wheatgrass, 5.13 t/ha (2.29 tons/ac); and meadow fox-tail, 4.84 t/ha (2.16 tons/ac). However, no grass-clover mixture yielded as well as a control mixture of Troy Kentucky bluegrass and Roamer alfalfa, 6.81 t/ha (3.04 tons/ac). The most uniformly balanced stands of

grass and clover were obtained for Kentucky bluegrass, timothy, meadow foxtail, and orchardgrass. Bromegrass, reed canarygrass, slender wheatgrass, and intermediate wheatgrass were weakened by repeated clippings and were dominated by the clover by 1974.

PLANT DISEASES

Diseases of Cereals

Common root rot. Estimated losses from disease in Saskatchewan were 12% in wheat and 14% in barley; they were comparable to the high losses recorded in 1973. Conversion factors derived from levels of disease and yields of plants in samples from selected fields were applied to disease levels in survey fields and used to calculate the losses.

Common root rot in wheat increased with depth of seeding. The effect was more pronounced at mid- than at late-season. Subcrown internodes, the part on which disease was rated, were longer with deeper seeding. When planted at similar depths, Chinook invariably had longer subcrown internodes than Neepawa, but it was more susceptible than Neepawa regardless of internode length.

A number of lines of wheat and barley selected for resistance in screening trials continued to perform well in replicated tests at several locations. Some of the wheat lines of diverse parentage will be crossed to seek progeny with exceptionally high resistance. Additional new wheat and barley lines were assessed and a small percentage merits further testing.

Conidia of *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur in the soil were more abundant after a barley crop than after wheat, and less abundant after rye and oats than after wheat. Sporulation on crowns of wheat plants was several times greater than that on subcrown internodes. Some fungicides applied to wheat plants between July 15 and 31 reduced formation of conidia, and when applied to stubble shortly after harvest some decreased the percentage of viable spores found in the soil.

No histopathologic differences were observed between cultivars that differed in resistance to *C. sativus*. Disease appeared to develop similarly in naturally and artificially infected subcrown internodes. Germinating conidia on the host's surface formed appressoria, or infection cushions, that produced

penetration pegs; these entered the epidermis directly. The pegs were subtended by lignitubers, but development was not inhibited. The fungus proceeded from the epidermis to the cortex and endodermis and caused cell breakdown. Sometimes the stele was invaded and vessels were occluded. Dark-stained objects of unknown origin and function occurred in some infected tissues.

Studies of somatic nuclei in *C. sativus* by means of light and electron microscopes showed that division took place within the nucleus. Haploid nuclei contained single nucleoli, whereas some diploid nuclei contained two. Spindle pole bodies were located opposite one another on the periphery of the nuclear envelope; a nuclear spindle developed. Chromosomes condensed at prophase, approached the equatorial plane at metaphase, and moved asynchronously at anaphase. Nuclei exhibited maximum elongation at telophase. New daughter nuclei were formed as the nuclear envelope in the interzonal region disintegrated. When examined by light microscopy, the nuclei, spindles, nucleoli, and chromosomes appeared larger, and the number of chromosomes greater, in diploid than in haploid nuclei. In culture, *C. sativus* readily used certain D amino acids as sole nitrogen sources but conidial morphology was altered by some of them.

Snow mold. Several psychrophilic fungi such as *Sclerotinia borealis* Bub. & Vleug., a low-temperature basidiomycete, and particularly *Typhula* sp. were shown to cause damaging snow mold in winter wheat and rye grown in test plots. One or more of these fungi or *Fusarium nivale* (Fr.) Ces. were involved in variably damaged commercial crops in northern Saskatchewan, after snow formed a deep and prolonged cover during the winter of 1973-74.

Diseases of Forage

Grasses. Heavy outbreaks of snow mold in 2- and 3-yr-old turfgrass plots resulted from artificial inoculation with the low-temperature basidiomycete. Although none of the strains of *Poa pratensis* L., *Festuca rubra* L., and *F. ovina* L. was immune, some of the introduced and local selections showed little initial damage, or rapid recovery, or both. The most effective fungicides for control of snow mold were chloroneb, inorganic mercury compounds, and quintozone where the

low-temperature basidiomycete or *Typhula* sp. were dominant in disease complexes.

Legumes. Callus and cell suspension cultures of several forage legume species have been established. They will be used to assay for chlorophyll-destroying metabolites produced by foliage pathogens.

Diseases of Oilseeds

Rapeseed. Screening of turnip rape, *B. campestris*, for resistance to white rust caused by *A. cruciferarum* was continued; several crosses involving resistant lines were rated highly resistant in field plots. Histological studies showed that the process of infection in cotyledons of several *Brassica* spp. was similar up to the time of formation of the first haustorium. In the resistant *B. napus* L., fungal growth was arrested and the haustoria encapsulated, whereas in susceptible *B. campestris* intercellular hyphae proliferated and additional haustoria were formed.

Of 610 seed samples of *Brassica* spp., 80% contained oospores of *A. cruciferarum*; the highest infestation level was 1,500 spores/g of seed. Oospores stored dry in the laboratory for 21 yr germinated well after they were washed in water.

Boron deficiency symptoms were induced in rapeseed plants in sand culture. Leaves turned purplish and became leathery, internodes were compressed, flower shoots withered, and roots were poorly developed and showed tissue breakdown. Boron corrected the disorder when applied at 0.5 ppm but was phytotoxic at 5.0 ppm. The symptoms of acute boron deficiency were similar but not identical with those of girdling foot rot.

When spores of *Alternaria* spp. were trapped in plots of *Brassica* sp., conidia were particularly prevalent when plants were in the seedling stage and when plants were near maturity.

ENTOMOLOGY

Rapeseed Insects

Bertha armyworm. Populations were very low across the prairies in 1974. Laboratory cultures were essential for continued work on this pest. With use of a new, improved artificial diet for the bertha armyworm, based on the lima bean diet of Shorey and Hale, more than 80% of the early-instar

larvae pupated successfully. Various modifications of this diet have been developed which enable larvae of the flax bollworm and the sunflower moth to be reared with equal success. The clover cutworm, *Scotogramma trifolii* (Rott.), appears to be the most likely alternate host for the parasite *Banchus flavescens* Cress., when field populations of the bertha armyworm are low. The clover cutworm is readily attacked, the parasite develops successfully in it, and field populations are present each year. Larvae of the cabbage looper, *Trichoplusia ni* (Hübner), were found to be unsuitable hosts for *B. flavescens* because all the young parasite larvae are sloughed off when the host casts its skin.

Wireworms

Feeding activity. In studies of the regulation of feeding and molting in wireworm larvae, surgical removal of the frontal ganglion prevented feeding but did not prevent molting. Larvae submitted to a sham operation without removal of the ganglion fed and molted, as did controls that did not undergo surgery. In tests with a series of large larvae, some of the controls fed before the first molt that followed several months of cold conditioning, and in tests with a series of medium-sized larvae most of the controls did so; nearly all fed actively after each molt. Ganglionectomized larvae molted normally at least once, although they did not feed before or after molting. In many cases, frontal ganglionectomy accelerated molting. Thus, molting in wireworm larvae is not dependent upon food intake, nor is it triggered by the stimulus of a period of feeding mediated by the frontal ganglion as has been demonstrated in locusts.

The frequencies of successive feeding periods in individual wireworms suggest that an internal rhythm is involved. Feeding usually occurs in the period immediately after molting, but larvae sometimes reenter an active feeding phase without molting. Thus, the feeding stimulus may arise independently and the molt may be omitted.

Grasshoppers

Abundance. Grasshopper infestations have increased each year since 1971. Surveys of the abundance of adults and eggs during late summer and fall in 1974 indicate that increased densities may be expected in 1975,

when the outbreak may be one of the most severe for many years if weather conditions are favorable, for example, if a warm, early spring is followed by a hot, dry summer.

Damage studies. Studies of the effects of grasshopper infestations on crop yields have revealed some interesting interactions between crop and insect dynamics, and have shown that weather could rapidly alter these relationships. Severe damage may be expected during hot, dry conditions, which favor the insects but inhibit crop growth. Under excellent crop-growing conditions such as those of the past few years, large yield reductions can occur only when populations of grasshoppers are very high. Losses were greatest when grasshoppers hatched early in the season and crops were in the early seedling stage; later hatching permitted the crop to develop well despite the grasshoppers, by increasing its foliage production. Three general types of damage to crops result from grasshopper depredation: early and complete destruction of seedling plants by invasion from field margins; late head-clipping, which occurs after all leaves are gone; and gradual defoliation throughout the season, which reduces both yield and grade of seed.

Analysis of results from damage studies in 1974, with grasshoppers caged over wheat plants in the field, indicates that the season was one of the most favorable for grasshopper survival and development for many years. As the weather was sunny and warm, the wheat seedlings in the cages were destroyed during the 1st wk of the experiment, and under similar conditions through the early summer the cages had to be moved to new plant stands as many as four times. The same result was evident in the field, where heavily infested areas showed considerable crop destruction. Consequently, one of the most intensive campaigns of grasshopper control in many years was conducted. Artificial defoliation experiments indicated that the period just before flowering, about mid-July, was the most hazardous to wheat plants.

Population studies. An empirical model for the prediction of hatching in the migratory grasshopper, *Melanoplus sanguinipes* (Fabr.), has been developed by use of daily maximum air temperatures from March to June. The model accounted for a maximum of 96% of the variance in hatching date. Analysis of

the model indicates that reproductive success of the grasshopper population is affected by the amount of embryonic development carried over from the previous fall, and by conditions of current season. If favorable temperatures continue for more than 1 yr, the carryover of development from year to year will tend to bring a greater segment of the population into the early laying segment, thus leading to a potential outbreak. On the other hand, if inclement weather persists, the depressing effects of the resultant delayed hatching may counteract the positive effects of early hatching on population growth, and this situation may be carried over from one year to the next.

A similar multiple regression model has also been developed for predicting the amount of embryonic development of the migratory grasshopper in the fall. The model indicates that the effects of previous population history, as represented by the estimated date of adult emergence, can be separated from the effects of temperatures in the current season. This finding should allow a method of estimating the impact of embryonic development in the fall on population trends.

Forage Insects

Sweetclover weevil. Further experiments were conducted on the damage to vegetative sweetclover stands in late summer and fall by the sweetclover weevil, *Sitona cylindricollis* Fähr. The experiments investigated the combined effects of clover defoliation early in the critical period by adult weevils and subsequent partial loss of clover top growth by normal swathing of the companion cereal crop at a height of 20 cm (8 in.). It was confirmed that 2nd-yr forage yield was reduced by half compared with that of a weevil-free, unswathed control. Root mortality, and to a lesser extent fewer crown buds per root, accounted for this reduction. Normal swathing alone did not significantly reduce forage yield. Also, normal swathing and subsequent defoliation by weevils after the critical period did not adversely affect the 2nd-yr forage yield.

Alfalfa plant bug. In 1974, an unprecedented outbreak of the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), occurred in alfalfa seed crops throughout Saskatchewan and southern Alberta. Infestations intense enough to cause total failure of the seed crop

were frequent; ones that could cause 30 to 70% seed loss were common. The application of recommended controls effectively reduced the infestations to noneconomic levels.

Mosquitoes

Abundance. In 1974, for the 3rd consecutive yr, mosquito populations in the agricultural area of Saskatchewan were comparatively small, being well below the average of the past 10 yr. *Culex tarsalis* Coq., the epidemic and endemic transmitter of the western equine encephalitis (WEE) virus, was more abundant than in 1973 but was still below the long-term average. *Culiseta inornata* (Will.) was generally the most abundant species during the season.

Arbovirus activity. In 1973, examination of 45,124 female mosquitoes for arboviruses yielded only one isolation of the WEE virus, and that was from *C. inornata*; no WEE virus infections were acquired by three indicator flocks of 75 chickens. In 1974, examination of 32,568 female mosquitoes yielded three WEE virus isolations from *C. tarsalis*, and 14 of 99 indicator chickens from four flocks acquired WEE infections. However, as forecast, no epidemic of WEE occurred in Saskatchewan in 1974 and no human cases were reported. Four out of 25 suspected WEE infections were confirmed in horses. Of 20 other arbovirus isolations made from mosquitoes in Saskatchewan in 1974, six are still unidentified, six were strains of California encephalitis virus, and eight were Cache Valley virus.

Insecticides. The organophosphate OMS 1155 (Dow Chemical Co. of Canada Ltd.), dimethyl analogue of chlorpyrifos, is less toxic to associated aquatic fauna than chlorpyrifos (Dursban; Dow Chemical Co. of Canada Ltd.). It was tested against mosquito larvae in naturally infested ponds near Saskatoon. OMS 1155 at 33.6 and 8.4 g/ha (0.03 and 0.0075 lb/ac) was completely effective in open ponds with sparse emergent vegetation. At 16.8 g/ha (0.015 lb/ac), it eliminated larvae by the 14th day after treatment. The insecticide was less effective at this median rate probably because it failed to disperse evenly through the dense emergent vegetation in the pond treated.

Flit MLO (Exxon), a surface-spreading oil, applied against mosquito pupae at 22.5 litres/ha (2 gal/ac) prevented emergence of adults; at 11 litres/ha (1 gal/ac) it allowed

only 4% emergence. When it was used against larvae, 67 litres/ha (6 gal/ac) were required to obtain similar results.

Ecology. Data were summed from a 3-yr investigation at a freshwater breeding site near Saskatoon, which was sampled for larvae and adults from snowmelt to freeze-up. The results showed that two rather distinct populations occur at pestiferous levels (at which they constitute more than 1% of the total mosquito population). This points up the need for separately timed operations to control the two groups. The first population, which arises from overwintered eggs, contains only the genus *Aedes*; the second, from overwintered adults, is comprised of the genera *Culiseta*, *Culex*, *Anopheles*, and *Mansonia*. Altogether, nine species of mosquitoes reached pestiferous levels of abundance in the experimental area in 1974.

The heat units required for development of larvae of *Aedes implicatus* Vockeroth in the field were 44, 33, 31, and 67 degree-days ($^{\circ}\text{C}$) above 4.4°C for the first, second, third, and fourth instars in that order. These requirements were almost identical with conditions needed for this species in the laboratory.

Black Flies

Ecology. The larvae of *Simulium arcticum* Mall. develop rapidly from overwintered eggs in the North Saskatchewan River. Analysis of data for 1972 showed that first-instar larvae first appeared on April 26, 6 days after the spring ice began to break up. At subsequent weekly intervals, larval instars 1 and 2, 1 to 4, 1 to 7, and 1 to adult occurred. Outbreaks commenced on May 25 and animal fatalities occurred irregularly from May 25 to June 30 from black flies that emerged from an untreated portion of the river. From April 26 to May 20 the densities of larval populations increased daily, not only because overwintered eggs continued to hatch but also because larvae drifted downstream.

Control. A single 7.5-min injection of 0.6 ppm methoxychlor into the North Saskatchewan River totally eliminated instars 3 to 6 inclusive of the larvae of *S. arcticum* from sites 40 and 80 km (25 and 50 mi) downstream, and removed 91% at 121 km (75 mi) and 66% at 161 km (100 mi). Of instars 1 and 2, 96% were removed from the most distant site.

The treated portion of the river was rapidly repopulated. At distances of 40, 80, 121, and 161 km downstream from the chemical injection point, populations of Chironomidae larvae, larger than 1 mm long, equaled or surpassed the pretreatment densities within 1–3 wk, Ephemeroptera within 1–4 wk, Trichoptera within 1–7 wk, Plecoptera within 4–5 wk, and Simuliidae within 2–10 wk; populations of newly hatched larvae reappeared in less time.

Pesticide Chemistry

Methodology. A method has been developed for the determination of thiram-³⁵S residues in animal tissues. The new method requires the digestion of animal tissue in an alkaline solution of sodium 2-hydroxymercuribenzoate. Typical recoveries from muscle, blood, liver, and fat of pheasants were 90%, and from kidney tissue, 70%.

A new method was developed for determining residues of carbofuran and 3-hydroxycarbofuran in flax seed. Extracts of the seed were partially cleaned, then derivatives obtained with trifluoroacetic anhydride were chromatographed and quantitatively analyzed. Carefully selected conditions of chromatography were essential to minimize the effects of interfering coextractives.

Translocation and retention. Sixteen months after application of insecticide to soil, the concentration of technical chlordane was still 60% of the initial concentration, the concentration of lindane was 40%, but the concentration of fonofos was less than 10% of the initial level.

Carrots grown in soil treated with fonofos in the previous growing season adsorbed small amounts of chemical (0.02 ppm), 100-fold less than the residue level in carrots grown the previous year; potatoes had only traces of fonofos. The concentration of lindane in carrots decreased by nearly 50%. Although the level of technical chlordane in

carrots decreased from that of the previous year, the level of residue in Norland and Kennebec potatoes grown under dryland or irrigated conditions increased; in Norland potato peels the increase was from 0.04 ppm (total alpha and gamma isomer) to 0.37–0.47 ppm.

Flax treated with carbofuran at 0.14 and 0.28 kg/ha (2 and 4 oz/ac) was analyzed for residues of carbofuran and 3-hydroxycarbofuran, but neither chemical was found in the harvested seed.

Pollution potential. A study was started to determine whether thiram, a fungicide used in seed treatment, would appear as a harmful residue in game birds. Pheasants fed thiram-³⁵S excreted about 8% of the administered dose in feces and urine within 27 h, and about 20% within 15 days. The amount of radioactivity in the exhaled breath could not be accurately measured. Female birds fed on a diet with thiram laid abnormal eggs, but returned to producing normal eggs when thiram was removed from the diet. Birds sacrificed 27 h after feeding had about one-quarter of the original dose in muscle and organs, and traces of activity in blood, bone, or feathers.

Insect Nutrition

Mycotoxin detection. Isolates of fungi occurring on cereal grains were fed in dietary substrates to larvae of the yellow mealworm to screen the fungi for mycotoxin production. Three isolates of *Fusarium roseum* Lk. emend. Snyder & Hansen, two of *F. equiseti* (Cda.) Sacc., and of *F. nivale* (Fr.) Ces., and one of an unidentified species of *Fusarium* caused growth depression of the larvae. One isolate of an unidentified species of *Myrothecium* was also toxic to the larvae. Mycotoxin production was apparently dependent on the specific fungus and the culture conditions under which the fungus was grown. Some fungal isolates had growth-promoting qualities for the larvae.

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INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on various soils, and cattle are raised on natural and cultivated grasslands. Small areas are irrigated. Research is focused on improving the economy and stability of this production.

Heavy snow in winter and above-average precipitation in May delayed spring seeding but provided the moisture base for an excellent crop. Lack of precipitation during June and July slightly reduced crop potential. Excessive moisture during August, combined with a late-August frost, reduced yield and quality of cereals.

A license was obtained for Canuck, a hard red spring wheat developed by Mr. D. S. McBean. The release of this sawfly-resistant cultivar that has better yield and quality than Cypress is very timely.

Before he retired in December, Mr. F. Bisal completed the development of a mathematical model that describes the rate of movement and total flow of windblown soil particles. This model is essential to an understanding of the physical components of wind erosion.

These and other research accomplishments are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report, from Mr. P. I. Myhr, or from individual scientists. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

A. A. Guitard
Director

CEREAL CROPS

Breeding and Evaluation

Canuck spring wheat. Canuck was licensed and the seed distributed during 1974. The cultivar was developed at the Station from a cross made in 1957 between Canthatch and a sawfly-resistant selection from Mida-Cadet-Rescue. It is an improvement over Cypress (the currently recommended sawfly-resistant cultivar) in yield, quality, and disease resistance. Similar to Cypress, the new cultivar has tall weak straw and a tendency to shatter. Canuck is rated equal to Marquis in quality. It is adapted to the drier prairie areas where sawflies are likely to infest wheat.

Drought tolerance in spring wheat. Three methods of determining photosynthesis were evaluated as possible screening tests for drought resistance in spring wheat. Potential photosynthesis in detached leaves, measured by the differential respirometer, was considerably higher in Pitic 62 than in Koga, Neepawa, or Wascana after a 4-h recovery from drought stress. Actual photosynthesis measured by infrared gas analysis varied slightly among cultivars after overnight recovery from drought. In moderately drought stressed plants, $^{14}\text{CO}_2$ incorporation

was only slightly higher in Pitic 62, but under severe stress it was twice as high as in the other cultivars. It appears that photosynthesis measured with a differential respirometer and $^{14}\text{CO}_2$ incorporation have potential as screening techniques for drought resistance.

Cold tolerance in winter wheat. Soluble carbohydrate patterns of two hardy winter wheat cultivars, Kharkov MC22 and Winalta, and two less hardy cultivars, Nugaines and Jones Fife, were compared during the cold-hardening process. Concentrations of soluble carbohydrates increased at different rates as the seedlings hardened. The largest soluble carbohydrate differentials developed in the sucrose and raffinose fractions with the accumulation greatest in the two less hardy cultivars.

Soil Nutrient Relationships

Nutrient uptake by wheat. In lysimeter tanks under low, medium, and high moisture tension, early application of N and P was essential for maximum yield and nutrient uptake by Manitou and Cypress wheat. There was a strong tendency to take up most of the N and a lesser tendency to take up P early in the season as the moisture tension increased. Manitou wheat was higher than

Cypress in both percent and total N uptake at each sampling period. ¹⁵N analysis showed that Manitou took up a greater proportion of fertilizer N. At tillering, the percent P was consistently higher in Cypress than in Manitou, but at maturity there was no difference between the two cultivars. Total P uptake was greater in Cypress than in Manitou when fertilizer was applied, but tended to be less when not fertilized.

Translocation of P into the kernels of windrowed wheat. When Chinook spring wheat was cut with a self-propelled windrower starting at 45% kernel moisture, there was movement of P from the straw into the kernel until the kernel approached 35% moisture. There were indications that this process does not require active metabolism.

Soil Moisture Relationships

Influence of stubble height on snow accumulation. During the winter of 1973-74, snow was measured on a wheat field where the crop had been swathed to leave the stubble at a uniform height of 15 cm and on a field where the wheat had been swathed at alternate heights to leave stubble 23 cm and 15 cm high. The alternate-height stubble trapped 4 cm more water from snow than the uniform height stubble. This exceptionally good accumulation of snow in the wheat swathed at alternate heights was possible because of an above-average snowfall of 185 cm. During some years, there would not be sufficient snow at any one time to fill to capacity even the 15-cm stubble. However, the study showed that, during years of adequate snowfall, some soil moisture advantage can accrue by managing the stubble for maximum snow-holding capability.

TURKEY NUTRITION

Dietary Fat

Effect of dietary fat concentration. The effects of up to 12.5% added dietary fat (ADF) and 10% increase or decrease in relative energy:protein ratio (E:P) on the performance at 4-wk intervals to 24 wk and the carcass composition of male turkeys showed that poult fed the low level of ADF required a narrower E:P to 4 wk and were more sensitive to E:P imbalance than those fed higher levels of ADF. The E:P requirement was less critical after 4 wk. Energy

conversion was more efficient with lower ADF to 4 wk, but became more efficient with higher ADF as the birds approached maturity. Energy utilization was more efficient and protein utilization less efficient with narrower than with wider E:P's. Increased deposition of tissue fat at high ADF levels may explain the increased energy tolerance of poult fed high-fat diets.

Carcass finish and tissue-fat deposition were influenced more strongly by the level of ADF than by varying the E:P. The pronounced influence of ADF on the skin and tissue fat of immature turkeys indicates the potential value of increased ADF in diets for early marketed small turkeys. The yield of carcass components other than skin was not strongly influenced by either ADF or E:P. Percent eviscerated carcass and edible meat yield increased with age. Percent yield of wing segments and drumsticks decreased with age. Skin yield and content of tissue fat first decreased, then increased with age.

Digestibility of rapeseed oil. The apparent digestibility of rapeseed oil by growing poult increased from 55% at 1 wk to 88% by 5 wk of age. Erucic acid was partly responsible for the low early digestibility of the oil. Therefore, a lower metabolizable energy value should be used for rapeseed oil in the formulation of diets for starting poult.

Amino Acids

Limiting amino acids in protein sources. Free amino acids in the blood plasma of poult fed diets based on four protein sources were determined to establish the order of limiting amino acids in each. Values of free amino acids in birds fed pea-protein concentrate indicated that methionine was the first limiting amino acid. The second limiting amino acid seemed to be in a group consisting of lysine, leucine, isoleucine, and valine. In soybean meal, the first, second, and third limiting amino acids were methionine, lysine, and threonine. In an unsupplemented herring fishmeal basal diet, free histidine and methionine levels were low. In poultry residue meal, lysine and histidine appeared to be the first and second limiting amino acids.

Evaluation of wheat cultivars. Wheat cultivars ranging in crude protein content from 10.8 to 17.1% were fed in computer-formulated diets to chicks and poult. The growth rate of chicks increased as the protein level of the wheat decreased in the order of

cultivars Chinook, Inia 66, Glenlea, and Lemhi 53. The differences were related to the dietary amino acid balance and are attributed to both the better amino acid balance in the lower protein wheats and the greater proportion of soybean meal used in diets containing lower protein wheats. The growth rate of poult was not related to the protein level of the wheat. Poults fed Chinook and Pitic 62 grew faster than those fed either Inia 66 or Glenlea, but not Lemhi 53. Feed conversion of diets based on Chinook, Inia 66, Glenlea, and Lemhi 53 did not differ in either chick or poult studies. However, the diet based on Pitic 62 was more efficiently converted by poults than were the other diets.

FORAGE

Breeding and Evaluation

Alfalfa. Levels of 19 amino acids were determined for 29 alfalfa cultivars. Expressed as grams per 16 g of N, levels of some of the more important amino acids varied as follows: lysine from 6.5 to 7.3, arginine from 5.3 to 6.3, threonine from 4.2 to 4.7, isoleucine from 3.7 to 4.4, leucine from 6.8 to 8.0, phenylalanine from 4.4 to 5.2, and aspartic acid from 10.6 to 14.0. Kane, Ladak, Rambler, and two experimental synthetics had the best balance of these amino acids.

Studies of total water use, water use per day, water use per unit of herbage production, and water use per unit of total plant productivity of 15 alfalfa genotypes from the three *Medicago* species indicated that selection for efficiency of water use in both limited and nonlimited soil moisture environments must be based on actual yield. If selection is not done in the field, then the artificial selection environment must be similar to the natural environment under which the alfalfa will be produced. It was found that alfalfas that grow slowly and are drought-resistant may have superior efficiency of water use but are less capable of high production.

Russian wild ryegrass. Studies of progenies from a five-genotype diallel cross indicate that 64% of the variation in date of head appearance can be attributed to additive genetic effects, and thus fast progress could be made in selection for early heading. Variance for seed yield was strongly additive

with specific combining ability also being important. About half of the variation in yield of dry matter was attributed to specific combining ability with 26% attributed to additive genetic effects. This suggests that diallel crossing of selected plants before formation of synthetic strains would be of value in improving yield of dry matter.

Segregation in populations derived by crossing heterozygous progeny of a variegated foliage plant and a normal green foliage plant produced a ratio of 12 normal green : 3 variegated : 1 albino, which indicates inheritance according to the dominant epistasis pattern for two factors. Progeny from a cross between normal green and yellow foliage plants were also grown in the field and classified into normal and yellow foliage plants. The yellow foliage character carried by this population was found to be monogenic and recessive.

Altai wild ryegrass. When progenies from a six-genotype diallel cross were studied in the field, variation in individual seed weight was evenly distributed among general combining ability, specific combining ability, and reciprocal or maternal effects. Variation in number of days from seeding to seedling emergence was influenced more strongly by reciprocal and specific combining ability effects than by general combining ability. Reciprocal effects were important in the control of leaf number during the first 2 wk of growth, but by 6 wk the additive general combining ability effects had contributed more than half of the variation in leaf number. Also, by 6 wk, tiller number was largely controlled by general combining ability, which indicates that good progress could be expected in selecting for this factor. Variation in date of head emergence indicated that 67% could be attributed to general combining ability and thus this factor should be responsive to selection. Variation in seed yield was found to be about equally divided between general combining ability and maternal effects. Variation in dry matter yield of adult plants was largely additive.

Establishment and Survival

Endosperm exhaustion in germinating grass seeds. When six species of grass were germinated for 21 days in darkness, maximum root and shoot length of a species did not occur on the same day. Endosperm exhaustion based on maximum length of the

root, shoot, and total plant occurred between 15 and 18 days after the initiation of germination. The amount of endosperm reserve varied widely among species, but all used their reserves in about the same amount of time. Russian wild ryegrass, Altai wild ryegrass, intermediate wheatgrass, and brome-grass lost more than 60% of their initial seed weight during germination, whereas crested wheatgrass and tall wheatgrass lost less than half of their initial weight. Loss of seed weight was a useful indicator of endosperm exhaustion.

Forage Yield

Pasture potential of Russian wild ryegrass, Altai wild ryegrass, and green needlegrass for grazing after seed production. Grazing after seed harvest resulted in increased seed yield of all three grasses the following year. Carrying capacities based on a 6-yr average were 83, 156, and 78 animal unit (au) days/ha and animal weight gains were 44, 58, and 44 kg/ha for Russian wild ryegrass, Altai wild ryegrass, and green needlegrass, respectively. Because Altai wild ryegrass has a deeper root system than Russian wild ryegrass or green needlegrass, it used soil moisture from a perched water table and this resulted in greater productivity. Green needlegrass did not compete well with weeds and had almost disappeared after 6 yr of grazing.

Winter pasture potential of Altai wild ryegrass. When bred Shorthorn females were grazed on Altai wild ryegrass during November, December, and January with access to only shelter, water, and salt, the animals lost weight at 0.67 kg/day. When the pasture was supplemented with 0.91 kg of chopped oats/animal per day, body weight was maintained. When fed 2.27 kg of oats/animal per day, the cows did not graze during stormy and severely cold weather. This resulted in under-utilization of the winter pasture. The stiff basal leaves of Altai wild ryegrass projected above shallow snow and remained erect in deep snow, which caused the snow to bridge across the plants. The cattle removed the snow with their muzzles and grazed the grass underneath.

Forage Quality

Alfalfa grown under irrigation. During an 8-wk growing period under irrigation, Roamer alfalfa accumulated dry matter in

the aboveground parts at about 6000 kg/ha. Stem yield increased linearly throughout the entire growing period. Increase in leaf yield was linear until flowering began, but was only slight thereafter. Thus, at the early flowering stage the yield of stems and leaves was equal, but at the late bloom stage stems made up 60% and leaves 40% of the total yield. With advancing maturity the nutritive value of the leaves deteriorated much less than that of the stems. N content declined 29% in leaves and 49% in stems from the early leaf to the late bloom stage. During the same period, P content declined 4% in leaves and 34% in stems and digestible energy declined 3% in leaves and 34% in stems. The composite result was a rapid increase in yield of nutrients up to the early bloom stage but only a slight increase thereafter.

Metabolic profiling of nutritional status. When bred ewes were fed alfalfa, a mixture of alfalfa and wheat straw, mature Altai wild ryegrass, or mature crested wheatgrass, blood urea nitrogen correlated well with protein digestibility of the feed and therefore showed promise as an indicator of protein nutritional status of the adult ruminant. Blood glucose did not appear to provide a satisfactory measurement of nutritional status, because for all diets it decreased with advancing pregnancy.

Flora of the Canadian Prairie Provinces

The second paper in the series "Biological flora of the Canadian Prairie Provinces" was published. The paper describes *Astragalus vexilliflexus* Sheld., which is an uncommon legume that has a limited distribution in Saskatchewan and Alberta.

ENVIRONMENT

Soil Nitrogen

Methods of estimating available N. When 12 chemical methods of estimating available N were each compared with the aerobic incubation method, the amount of N released in a dilute solution of CaCl_2 gave the best index of available N. This method consistently gave the highest correlation with the aerobic incubation method and also with the total N uptake by wheat grown on stubble with various levels of N supplementation.

Effect of soil temperature, moisture, and $\text{NH}_4\text{-N}$ on soil N. When Wood Mountain loam was wetted with water or a solution of $(\text{NH}_4)_2\text{SO}_4$ and incubated in polyethylene bags buried 2.5 cm deep in summerfallow or in an incubator that simulated the diurnal temperature patterns recorded in the field, the incubator satisfactorily simulated the effect of growing season temperatures on soil N transformations. Pronounced increases or decreases in temperature led to flushes of N mineralization. Comparison of the nitrification occurring in laboratory-incubated soils with that occurring in the field indicated that 70–90% of the $\text{NO}_3\text{-N}$ produced in the surface soil resulted from wetting and drying. At 10, 15, and 20% moisture, the average potentially ammonifiable soil N was 27, 41, and 82 ppm, respectively. The time required to mineralize half of the potentially ammonifiable soil N was about 7 wk.

Relationship between $\text{NO}_3\text{-N}$ in summerfallowed surface soil and some environmental variables. When measurements were made on summerfallowed Wood Mountain loam in the field and when temperatures and wetting and drying conditions measured during one growing season were simulated in the laboratory using three soils, the most important factor influencing $\text{NO}_3\text{-N}$ change was wetting and drying. The effect depended on the soil moisture content just before the change occurred and on the temperature during the period of change. Nitrification accounted for 12% of the increase in $\text{NO}_3\text{-N}$ in the top 2.5 cm of soil and 88% resulted from upward movement and deposition of $\text{NO}_3\text{-N}$ salts near the soil surface as a result of evaporation. Of the $\text{NO}_3\text{-N}$ produced by nitrification in the Wood Mountain loam, about 17.4% was accounted for by temperature effects. Thus only about 2.1% of the $\text{NO}_3\text{-N}$ increase in the top 2.5 cm of soil in the field was caused by temperature. In the simulation study, 19°C appeared to be the critical temperature above which the rate of nitrification was sufficient to compensate for $\text{NO}_3\text{-N}$ losses resulting from leaching and denitrification. The effect of moisture change on $\text{NO}_3\text{-N}$ change appeared to be directly proportional to the total C and N content of the three soils.

Influence of Soil and Climatic Factors on Response to Fertilizer of Wheat Grown on Stubble

Field tests were conducted to determine the effect of soil moisture and nutrient content at seeding, rainfall during the growing season, and rainfall deficits for half-monthly periods during the growing season on the response to N and P fertilizers of wheat grown on stubble. In general, climatic factors during the growing season were important in causing yearly variations in the unfertilized plots, but soil moisture and nutrient status at seeding had the greatest influence on the response to fertilizer.

Determination of the Amount of Soil Removed from an Erosive Soil Surface

Soil erosion by wind may be defined as initiation, transportation, and total amount of soil removed from a specific area. Empirically the amount of soil removed from a specific area varies as the velocity gradient V_*' . The general equation is:

$$q^1 = K(V_*')^P \quad (1)$$

where q^1 is the mass of soil removed from a soil tray of width y in a time period (tp); K is a parameter and P the exponent to be determined. The experimental values of the exponent were found to range from 2.1 to 5.1 with a mean value of 3.2 in 21 randomly selected tests.

The physical interpretation of the above equation can also be approached by means of dimensional analysis to determine the exponent. The work done by the wind is equal to the pressure of the wind, multiplied by the area on which it acts, times the distance x in the direction of this force. The equation is:

$$\frac{1}{2} \rho \frac{x^2}{t^2} yzx. \quad (2)$$

This is equal to the work by the soil

$$K_1 MgZ \quad (3)$$

where Z is a function of x . Equating equations (2) and (3) results in:

$$\frac{1}{2} \frac{\rho x^2}{g t^2} \cdot yx = K_1 M; \quad (4)$$

when equation (4) is divided by time (t) and multiplied by the time period (tp), and

using the parameter K_2 in place of K_1 the result is:

$$\frac{\rho x^3}{g t^3} \cdot ytp = K_2 M. \quad (5)$$

$\frac{x}{t}$ can be replaced by the velocity (v). A

conversion from velocity to velocity gradient* (V'_*) and if $1/K_2$ is replaced by C , the equation is then:

$$M = C \frac{\rho}{g} (V'_*)^3 ytp. \quad (6)$$

Based on experimentally determined values and by means of dimensional analyses, the amount of soil moved from an erosive surface varies as the velocity gradient cubed. The average rate of flow for the time period also varies with the same exponential power.

RESEARCH EQUIPMENT

A Two-row Harvester for Lodged Cereal Grain

A machine was designed and constructed to harvest moderately to severely lodged barley in small plots on irrigated land. The machine is powered by a 7-hp air-cooled motor operating at 2500 rpm. A transaxle provides forward speeds of 1.36, 2.19, and 3.23 km/h and a reverse speed of 1.70 km/h. Positive traction is provided by 5×12 ground-grip tires. The machine is 2.30 m long, 0.68 m wide, and 0.85 m high. The cutting bar is 35 cm wide and 15 cm high. Japanese raising fingers angled at 45° replace the conventional reel. The total weight of the machine is 160 kg.

The machine will harvest two rows, from 23 to 27 cm apart, in a single pass. Any tangled and fallen grain between the two inner rows and the outer rows is separated by the dividing heads. The grain stalks are grasped by the fingers as they rise from the lower inside corners of the dividing heads, lifted to an erect position, cut by the knife,

and deposited in the sample pan. The sheaf can be removed from the pan in about half the time required for a machine with a conventional reel. The compacted sheaf can be bagged or laid out on the plot stubble for field drying and subsequent threshing.

Tillage and Seeding Equipment for Indian Agriculture

For the past 2 yr the Station has participated in a training program for Indian design engineers. Each training program culminates in the design and construction of a machine that is thought to have potential for farm use in India. These machines are subjected to preliminary testing in Canada and then sent to India for final evaluation by their designers. The following machines have been developed.

Dryland ridger-seeder. This is a 3-point hitch tractor-mounted machine with three ridgers and associated seeding equipment. Ridges from 20 to 60 cm wide and furrows from 25 to 45 cm wide can be formed by the machine. For kharif seeding two rows can be planted on each ridge, and for rabi seeding one row can be planted in the moist soil at the bottom of each furrow and fertilizer placed 2.5 cm below the seed.

A bullock-drawn multipurpose tillage and seeding machine for Maharashtra State. This machine was designed for primary tillage and seedbed preparation, seeding and fertilizing, interrow cultivation, or a combined tillage-seeding operation. It is a three-row seeder with a variety of openers for placing seed and for placing fertilizer in bands beside the seed.

A seeder for the plateau region of Bihar State. This is a two-row bullock-drawn machine for placing seed and fertilizer during both the kharif and rabi seasons. Hoe openers were designed to place seed and fertilizer in bands about 2 cm apart. For rabi seeding modified cultivator sweeps precede the seed openers, pushing the dry soil aside. The machine can also be used for cultivation.

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INTRODUCTION

The Northern Research Group, which comprises the Research Station at Beaverlodge and the associated experimental farms at Fort Vermilion, Alta., and Prince George, B.C., continued research on agricultural problems of northwestern Canada. This report presents highlights of research in 1974.

Research centering on the relationship between crops and environment continued to be a major concern of the group. Our apiculture research program was strengthened by the appointment of another scientist. Forage research was highlighted by the introduction of Dawn, a new diploid alsike clover. Our tomato breeding program produced the new cultivars Sub-Arctic Cherry and Sub-Arctic Maxi.

Research on production and management of forage crops continued as the main activity at Prince George and Fort Vermilion, and forage utilization was also studied at Prince George.

The Northern Research Group is pleased that the Station's ecologist helped the Department of Indian and Northern Affairs by studying and reporting on agricultural potential in the Yukon Territory, and on the land capability of the Mills Lake area of the Northwest Territories.

This report and reprints of the publications are available on request. Correspondence to individual research scientists should be addressed to: Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0; Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0; or Experimental Farm, Research Branch, Agriculture Canada, Prince George, B.C. V2N 2H8.

L. P. S. Spangelo
Director

APICULTURE

Behavior

Acceptance and attractiveness of queens. An introduced queen was accepted by 7-day-old workers but was usually rejected by workers 14 or 21 days old. Aggression by workers increased linearly with their age (8–12 days) and depended on whether the introduced queen had been stored in a queen-right, queenless, fed, or unfed colony. A queen up to 7 days old or more than 35 days old was most readily accepted; queens 14, 21, or 28 days old were usually rejected. Aggression of workers depended on the queen's age and attractiveness, the latter being the most important factor.

Each queen had a particular degree of attractiveness. Workers accepted their own queen or a strange queen of similar attractiveness, but rejected one whose attractiveness differed. Some colonies were more attracted to queens than were others. The queens' weight at emergence was linearly related to their weight when laying (at 2 mo old), and heavier queens were more attractive to the workers.

Workers were attracted to polystyrene lures that had been rubbed against a queen's head or abdomen. An ether extract of laying queens was more attractive than one of virgin queens, and the number of workers attracted to queen extracts at increasing concentrations followed a curvilinear regression.

When two queens met they showed aggression, nonaggression, or avoidance. Aggression was greater between queens of similar age and condition. Hostility was not affected by removal of mandibular glands and was not related to the queens' weights, although starvation reduced aggressiveness. The initial attacker was usually the victor.

CEREAL CROPS

Physiology

Yield development in isogenic barley lines. Four backcross-derived, isogenic lines of Atlas barley that differed in awn length (full-, half-, quarter-awned, and awnless) were grown for 3 yr at Beaverlodge. The half-awned line gave the highest average yield, 5% more than that of the awnless line. Seed

weight was linearly related to awn length, and greater awn length was associated with a reduction in the number of spikes and florets per plant. The magnitude of the latter two components may depend partly on competition for nutrients, during early development of the spike, between the awns at the base of the spike and the developing florets at the tip. Long days may put the full-awned line at a further disadvantage in terms of yield at Beaverlodge.

ENVIRONMENT

Plant Survival

Water permeability and cold hardiness. The relationship between resistance to freezing and water permeability of cortex cells was studied in stems of red-osier dogwood (*Cornus stolonifera* Michx.). Permeability was estimated by determining the diffusion flux of tritiated water from slices previously equilibrated in tritiated water. Energies of activation and diffusion times were examined to compare the flux of tritiated water from living cortex slices with the flux from slices killed by immersion in liquid N₂. The comparisons verified that intact membranes of uninjured cortex cells limit water flux.

Water permeability of living phloem and cortical parenchyma cells increased during the initial (photoperiodically induced) phase of cold acclimation. This accompanied an increase in hardiness at temperatures from -3 to -12°C. Little, if any, further increase in permeability was noted during subsequent acclimation to below -65°C.

Measurements of permeability performed on nonhardy cortex samples yielded consistent results, but measurements on samples from hardy twigs were often difficult to reproduce. This unexplained variability precludes specific conclusions, but the technique based on the diffusion flux of tritiated water may provide an alternative to traditional plasmolytic techniques in studies of water permeability in woody plant tissues.

This research was conducted in cooperation with Dr. C. J. Weiser at the Laboratory of Plant Hardiness, University of Minnesota.

Crop Diseases

Disease assessment. Previously unrecognized damage from snow mold, attributed to *Sclerotinia borealis* Bubak & Vleugel, to seed stem initials of creeping red fescue was the

most serious disease of fescue, and was estimated to have caused a regional average loss of 24% in seed production. Losses of newly seeded fescue were severe in the area of Beaverlodge and were as high as 40% in some fields. Damage to fescue seed from stem eyespot was low for the 2nd yr. Losses of winter rye caused by snow mold were the most severe in the region since 1930 and in some fields the crop was a total loss. Snow mold also seriously damaged brome grass, timothy, and orchardgrass.

In alfalfa and clover, the disease complex of crown rot, root rot, and winterkill caused most losses, although common leaf spot and yellow leaf blotch on alfalfa and powdery mildew on the clovers were extremely prevalent. Foliage diseases of forage crops were generally light.

Common root rot was the most prevalent and serious disease on all cereals, barley scald being the only other cereal disease of significance. Brown girdling root rot, whose cause is not yet determined, was the most serious disease of rape for the 2nd yr, followed by staghead. Early infections of black leaf spot (*Alternaria* sp.) on lower leaves of rape did not spread to a significant extent to stems and pods. Root rot of flax was common but light. Mycotoxins of several types continued to be a sporadic but serious problem. These mostly originate from feed grains that were not harvested until spring.

Weed Control

Control of narrow-leaved hawk's-beard in creeping red fescue. Fall applications (early to mid-October) of 2,4-DB at 1.4 kg/ha or more and 2,4-D ester at 1.12 kg/ha consistently provided good control of hawk's-beard in established creeping red fescue over a 3-yr study period. A combination of dicamba, 2,4-D, and mecoprop at 0.13, 0.35, and 0.08 kg/ha, respectively, applied at the same time provided good control in 2 out of the 3 yr. With each of these treatments the hawk's-beard plants were not immediately killed, but rather became severely distorted and died during the following spring. Injury to fescue was not apparent from any of the treatments. Spring applications (early to mid-May) of 2,4-DB at 1.4 kg/ha, 2,4-D ester at 1.12 kg/ha, and dicamba at 0.13 kg/ha plus 2,4-D at 0.35 kg/ha plus mecoprop at 0.08 kg/ha also controlled hawk's-beard. However, the application of 2,4-D reduced seed yields of fescue

in 1973 and the treatment with dicamba plus 2,4-D plus mecoprop reduced fescue height severely in 1974.

Effect of herbicides on seed yield and quality of red clover. Field studies on effects of herbicides were conducted in established stands of red clover in 1972, 1973, and 1974. MCPA at 0.28 and 0.56 kg/ha, MCPB at 1.12 and 1.68 kg/ha, and bromoxynil at 0.28 and 0.42 kg were applied in spring, either as the red clover was beginning to break dormancy or when it was 7.5 to 10.0 cm high. The applications did not affect seed yield or germination. The treatments with MCPB and bromoxynil had no effect on seed weight, and MCPA reduced seed weight only in 1973 when applied at 0.56 kg/ha to red clover in the 7.5- to 10.0-cm stage.

The other herbicide treatments evaluated in the study (2,4-D at 0.28 and 0.56 kg/ha and 2,4-DB at 1.12 and 1.68 kg/ha) do not appear to have a potential for weed control in seed-producing fields of red clover. They consistently delayed crop maturity, reduced seed yields in 1973, and reduced seed weights in 1972.

FORAGE CROPS

Breeding

Alsike clover. Dawn, a new cultivar selected for herbage yield and winter survival, was licensed in April 1974. It is a nine-clone synthetic of the diploid type produced by the polycross method. In tests across Canada, Dawn produced up to 14% more herbage and had a 10% higher winter survival rate than Aurora. Dawn will replace Aurora as the recommended diploid alsike clover. Breeder seed of Dawn, from the Syn-2 generation, is being released for the production of Foundation and Certified generations under contract to the Canadian Forage Seeds Project.

Seed Production

Companion crops for alsike and red clover. First-year seed yields from clovers seeded without a companion crop were 675 and 750 kg/ha for red and alsike clovers. Seed yields were consistently lower when clovers were established with barley, oats, flax, or rape. Rape was the most competitive crop, causing yield reductions of 50 and 40% for red and alsike clovers.

Seeding rates for red fescue seed fields. Seeding rates were evaluated as a means of maximizing seed yields of red fescue in the 1st yr, when infestations of the stem eyespot disease, and associated seed losses, are at their minimum. Seed yields increased from 430 to 725 kg/ha as seeding rates were increased from 1 to 10 kg/ha. Yields declined sharply when seeding rates higher than 10 kg/ha were used. Plots seeded at 40 kg/ha yielded less than 100 kg/ha.

Herbage Production

Effect of nitrogen on meadow foxtail. Spring application of N at several rates increased the yield of dry matter and contents of crude protein, Cu, K, and Zn of meadow foxtail (*Alopecurus pratensis* L.). The amounts of P, Ca, Mg, and Mn present in the plants declined as the rate of N application increased. Application of P, in combination with N, increased the plant K content and prevented the decline of P content resulting from N application. The levels of digestible dry matter and Cu declined in successive cuts whereas Mn content increased. At low rates of applied N, the Ca and Mg contents of the plants also increased as the season advanced.

Mineral composition of cereal silage. Variation of species, cultivars, and locations did not affect the P content and Ca:P ratio of spring cereals harvested at the soft-dough stage. Calcium and K contents were influenced by differences of location and cultivar. The contents of Mg, Mn, and Cu varied according to the cultivar. Mo content was not influenced by the cultivar or location. Pitic 62 spring wheat was lower in Ca, K, Mg, Zn, Mn, and Cu contents than several oat and barley cultivars. The barley cultivars and Rosner triticale contained more Zn than the oat cultivars. The oat cultivars contained more Mn than most of the barley cultivars.

Influence of barley morphology on forage yield and quality. Forty cultivars of barley from the World Collection were grown to test the effect of height, row, and awn types on forage yield and quality. At the soft-dough stage, two-rowed cultivars produced more dry matter and more leaves, contained less head and sheath material, and were less digestible than six-rowed cultivars. Hooded cultivars produced more stem and leaf material and less head, sheath, and digestible dry matter than smooth-awned cultivars, but the

types were equal in dry matter yield. Tall cultivars produced more dry matter and stem and leaf material but were lower in crude protein, dry matter digestibility, and head contents than short cultivars.

HORTICULTURE

Breeding

New tomato cultivars. The tomato breeding project was completed with the introduction of two new cultivars. Both have excellent fruit-set ability at cold and high temperatures, good cotyledonary branching, large trusses, and early, even ripening. No blossom-end rot or cat-face and few large blossom-end scars have been observed.

Sub-Arctic Cherry was selected from the backcross (Mini Rose \times Early Sub-Arctic) \times Early Sub-Arctic and tested under the number NRG 7249. It ripens up to 30 days earlier than Tiny Tim and Mini Rose and 5 days later than Early Sub-Arctic. Plants are compact and determinate, with a spread of 55–60 cm. Fruits are produced in trusses of 20 or more, have good flavor, and are smooth, uniform green (u), round, 2–3.5 cm in diameter, and bright red when ripe.

Sub-Arctic Maxi was selected from the backcross NRG 6809 \times (Sub-Arctic Plenty \times NRG 6809) and tested under the number NRG 7262. It ripens up to 10 days earlier than Booster, Pembina, Melfort, and Early Tanana. It has better resistance to cracking, better yield than all but Swift, and equal or better size than all but Melfort. Plants are compact and determinate with a spread of

60–65 cm. Fruits are produced in trusses of 8–16, have mild flavor, and are smooth, uniform green (u), 4–8 cm in diameter, 3–7 cm long, and bright red when ripe.

SOILS

Soil Fertility

Effect of organic materials on acid soils. Addition of alfalfa meal, sucrose, and peat moss to very acid soil at 3% of soil weight resulted in alfalfa yields of 15.9, 0.1, and 3.3 g/pot, respectively. Alfalfa grown on soil with no amendment yielded 0.7 g/pot. Incubation of the soil with the amendments for 3 mo before alfalfa was planted resulted in yields of 2.2, 10.5, 6.1, and 2.2 g/pot from soils with no amendment and with alfalfa meal, sucrose, and peat moss.

The benefit from the alfalfa meal occurred because of its action in complexing exchangeable Al. Its water-soluble component was mainly involved in formation of the Al-organic matter complexes; the release of NH_4 as the meal decomposed was not considered a major cause of the decrease in exchangeable Al, because exchangeable NH_4 increased largely after the decrease of the latter.

Although the addition of these large quantities of organic materials to very acid soil produces many of the beneficial effects that would result from liming, the effects are temporary, lasting only a few months under greenhouse conditions. Thus, the addition of large quantities of organic materials cannot be considered a satisfactory substitute for liming of very acid soils.

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INTRODUCTION

The importance of replicating plots and locations in plant research was reemphasized this year when the tests at Lacombe were negated by hail. Fortunately most of the plots were replicated at off-station sites.

Plant disease surveys point up the need for continuing research to introduce resistance and to develop controls. The newer herbicides for combating wild oats are resulting in more effective control over longer growth stages of the weed.

The first report on the evaluation of the foreign cattle breeds was published in cooperation with Brandon and Lethbridge. The importance of controlling stress on young calves, even the seemingly small matter of providing areas for normal rest, was revealed in studies on calf scours.

This report is a summary of the main findings of the research program at Lacombe in 1974. Further details are available. Please address correspondence to: Research Station, Research Branch, Agriculture Canada, Lacombe, Alta. T0C 1S0.

J. G. Stothart
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ANIMAL SCIENCE

Beef Cattle

Crossbreeding. Reproductive efficiency of 1000 first-cross (F₁) heifers representing nine crossbred combinations between Charolais, Limousin, and Simmental bulls and Angus, Hereford, and Shorthorn cows has been evaluated in comparison with a control comprising 150 Hereford × Angus heifers. The control had a slightly higher conception rate, lost fewer calves at birth (because of lighter birth weights), and weaned a larger number of calves per 100 cows entering the breeding herd. However, this advantage was offset by the lighter weight of control calves at weaning and the lowest weight of calf weaned per 100 cows entering the breeding herd. The heaviest weaning weights were recorded for the breed crosses produced by Shorthorn dams and Simmental sires.

Correlated selection responses. Eleven years of selection for yearling weight in two herds of Shorthorn beef cattle has resulted in an increase (over a genetic control) of 41.5 and 46.2 kg in this trait. Correlated increases were observed in birth weight (3.6 and 3.0 kg), weaning weight (16.2 and 7.8 kg), and daily gain from birth to 12 mo of age (104 and 118 g). Indirect responses on measures of carcass merit were small with the selected line having a slightly larger percentage of bone (0.6 and 0.7%) and a corresponding reduction in lean-to-bone ratio of the major carcass cuts (-0.19 and -0.11).

Control of calf scours. Research observations have demonstrated the importance of various stress conditions on the incidence of calf scours. The weather during and immediately following calving may impose considerable stress on calves, but this can be effectively countered by providing shelter from the wind and dry bedding areas. The major source of stress arises from factors that interfere with normal rest requirements of the calf. Subdivision of the cow herd into groups of 35-40 head, adequate area (4-5 ha), similar age of calves in each group, and minimum handling of the calves and cows during the first month after calving have been found effective in reducing stress.

Calf scours and subsequent performance. Severity of infection, as rated by the length of treatment required to effect a clinical cure, has not been found to adversely affect subsequent performance (weaning weight and postweaning growth) in the experimental herd. Analysis of data for treated and untreated calves, the latter having no history of infection, also showed no statistically significant differences in postnatal performance of these two groups.

Meats Research

Prediction of carcass lean in live animals. Lean content of living animals was measured on 83 bulls, 33 heifers, and 20 steers using the K⁴⁰ technique. Regression studies indicated that live weight explained 3.5% of the total variance in lean content measured by

laboratory dissection of half of each carcass. Addition of a single K^{40} count to the regression equation increased the proportion of variance explained to 64.9% with a residual standard deviation of 1.4%, compared to an original value of 2.3%. Repeatability of duplicate K^{40} readings was high ($r = 0.97$). These results show that the technique has merit for evaluating the lean content of carcasses of live animals.

Quantity-quality relationships in pork. Increasing subjective color-structure scores (i.e., increasing desirability) of the longissimus dorsi were accompanied by significant ($P < 0.05$) increases in 40 min in pH, color brightness, and marbling score, and decreases in percent transmission and shear value. Scores were unrelated to degree of fatness but tended to decrease slightly with increasing muscle-to-bone ratios. However, all measures of carcass composition showed low correlation with the measures of meat quality.

Beef muscle pH and color. Postmortem measurements of muscle pH in beef cattle not subjected to excessive preslaughter stress showed low correlation with measures of tenderness and water-holding capacity of muscle. Glycolization rate post-mortem, as measured by pH change, differed for the four muscles semimembranosus, adductor, longissimus dorsi, and brachialis ($P < 0.05$) but within-carcass correlations were high. Color brightness of the longissimus dorsi of bull carcasses was positively correlated ($r = 0.75$) and shear force negatively correlated (-0.56) with pH at 24 h post-mortem. Correlations obtained with steers and heifers were much lower, and detailed analyses of the data revealed that the high values for bulls resulted from a bimodal distribution of glycolytic rates for this sex. Bulls subjected to preslaughter stress had high pH values, high (darker) color scores, and produced meat with lower shear values. Bulls not subjected to such stress provided correlations and averages for the traits measured that were closely comparable to the other two sexes.

Physiology

Weights of endocrine glands in beef cattle. The weights of thyroid, adrenal, pituitary, and brain were first determined in 1971 in 492 market weight purebred Shorthorns and crosses of the foreign breeds Charolais, Simmental, and Limousin with Hereford,

Angus, and Shorthorn. Thyroid weights were also determined in a similar group of 433 cattle in 1972. The data were reported on a per 100-kg body weight basis and analyzed within the subgroups of breed of sire, breed of dam, and location.

The average thyroid weight per 100 kg of body weight for bulls within subgroups over the 2 yr was from 3.99 to 8.71 g, whereas that for steers was from 3.81 to 4.41 g. The average thyroid weight for a group of 18 heifers was 3.71 g. The average adrenal weight per 100 kg of slaughter weight was from 3.66 to 4.20 g in bulls and from 3.66 to 3.86 g in steers. Pituitary weight per 100 kg of body weight at slaughter was from 386 to 511 mg in bulls and from 469 to 510 mg in steers. Average brain weight was from 85.5 to 97.3 g in bulls and from 92.2 to 94.1 g in steers.

Breed differences existed only for the pituitary gland; Simmental-sired bulls and steers have heavier glands than those sired by Charolais.

Sex differences were significant for the thyroid and the brain. Thyroids of bulls were generally heavier than those of steers, whereas brains of steers were heavier than those from bulls.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Barley breeding. Unitan, a six-row introduction from the USA, is proving a good source of disease resistance in the barley program at the Station. It has shown good resistance to scald, *Rhynchosporium secalis* (Oud.) Davis, and net blotch, *Helminthosporium teres* Sacc., and the Trebi-type resistance to loose smut, *Ustilago nuda* (Jens.) Rostr. These three diseases and common root rot are the main diseases of barley in central Alberta. Unitan has been crossed with Gateway, Galt, Bonanza, Keystone, Trent, and Wolfe and several advanced lines will be yield tested in 1975.

Oat breeding. Two years of tests of lines from the oat crosses Forward/Pendek, Random/Forward, and Random/Fraser have shown that 57, 65, and 65% of the lines, respectively, produced yields superior to that of Random, the control cultivar; 18, 22, and 39% of the lines outyielded Random by 10%

or more. Of 30 lines tested in 1974 at four to seven locations, 10 exceeded Random in yield by 10% or more, and 18 outyielded the control by a lesser amount. Although the growing season in 1974 was not ideal for rating maturity, the maturity and lodging of most of the high-yielding lines compared favorably with Random. The highest-yielding line, from the Random/Forward cross, also had a much plumper kernel than the control.

A Lacombe oat selection, 337-99 (Glen//Beacon/Laurel), has been recommended for licensing by the Alberta Cereal and Oilseeds Advisory Committee. It combines early maturity with high yield when grown in Alberta.

Disease Surveys

Survey of barley diseases. In the 1974 survey of barley diseases in central Alberta, common root rot was the most serious disease, causing about 11% loss. Scald caused 3.5% loss and net blotch 1%. Smuts, spot blotch, septoria leafspot, and bacterial blight all caused well below 1% loss, and the total estimated loss for all diseases was 16.7%.

Survey of rapeseed diseases. Rapeseed diseases in central and northern Alberta were surveyed in 1972 by sampling 141 fields. The most serious disease was root rot, which affected 12% of the roots. Staghead affected 0.5% of the heads and the percentage loss was the same. White rust of the leaves was found affecting 0 to 17.5 leaves, averaging 2.5%, and black spot 0 to 7.1 leaves, averaging 1.5% of the leaf area. In 1973, in cooperation with the Research Station, Lethbridge, the survey was extended to include southern Alberta.

Survey of forage diseases. The 1974 estimates of percentage loss from foliar diseases of forage crops were well below the 1970-73 average, in spite of the generally moist weather, which had been expected to increase severity of disease. Losses for the various species in 1974 and the average for the previous 4 yr given in parentheses were alfalfa 3.94 (6.27), red clover 3.68 (11.84), alsike clover 5.48 (10.17), brome 1.23 (2.13), and timothy 0.76 (1.52)%.

CROP MANAGEMENT AND SOILS

Weed Research

Selective control of wild oats in barley with AC 84777. A series of field plot experiments showed that AC 84777 (Avenge; Cyanamid of Canada) applied as a postemergence herbicide provided selective control of wild oats in barley equal to or better than barban over a growth period of the weed extending from the two- to the five-leaf stage. Barban must be applied at the two-leaf stage of the wild oats to achieve effective control. AC 84777 increased in efficacy as the wild oats advanced from the two- to the five-leaf stage.

Laboratory experiments showed that spot applications of technical grade or of ^{14}C AC 84777 entered the leaf of wild oats or barley and moved very quickly in an acropetal direction. It concentrated in the leaf tips in 30 min. Spot applications made at the midpoint of the first through to the fifth leaf of wild oats resulted in a concentration of AC 84777 and necrosis of the leaf area only above the point of application. Application at or below the growing point also resulted in rapid upward movement of the herbicide in both wild oats and barley but caused necrosis and death of the growing point and eventual death of only the wild oats. Histological studies of the growing points of these plants showed extensive chromosome clumping, shrinking, and necrosis of the cells. Plants that only had the midpoint of one of their leaves treated had histologically normal growing points.

Wild oats herbicides show synergism. Under controlled environment (growth cabinets) and field conditions, the efficacy of barban and AC 84777 alone and in mixtures for control of wild oats in barley was determined. Both barban and AC 84777 applied separately at the two-leaf stage of wild oats gave acceptable control. However, applied at the four- to five-leaf stage of wild oats, only AC 84777 was effective. Mixtures of AC 84777 and barban at about half the dosage recommended for either herbicide applied alone resulted in control of wild oats equal to or greater than either compound applied separately. This synergistic effect tended to be greater when application was made at the later five-leaf growth stage of wild oats. This herbicide combination has a promising future because it extends the growth period

during which wild oats can be effectively controlled with postemergence herbicides and at current prices is less expensive than AC 84777 used separately.

Over the past 2 yr of testing, WL 29761 (Shell Co.), an analogue of benzoprop, has shown much greater efficacy in controlling wild oats in wheat than has the original herbicide when applied during the three- to five-leaf growth stage of the weed. Crop tolerance has been very high. Although mixtures of WL 29761 with barban did not significantly enhance the control of wild oats when applied at either the three- or five-leaf stage of the wild oats, control tended to be slightly better at the early stage.

Residual effect of glyphosate on quack grass and barley. An area of deep, black loam soil infested with quack grass was sprayed with glyphosate at 0, 1.12, 2.24, and 3.36 kg/ha on May 15, 1973, when the weed was 10 cm tall. The shoots of quack grass withered within 7 days of treatment, after which the entire plot was rototilled and seeded to barley. Barley yields on the treated areas were nearly double those on the unsprayed area. The plot was rototilled and seeded to barley in 1974, but no further glyphosate was applied. Regrowth of quack grass in 1974 on all the areas that had been treated with glyphosate in 1973 was negligible. Barley yields were again more than double those on the unsprayed area.

Effect of duration of competition of wild oats on barley and rapeseed. Replicated field plots of barley and rapeseed were seeded with a uniform, heavy infestation of wild oats and with weed-free controls. Successive treatments were hand-weeded at intervals of 7–10 days until just before heading. Decreasing yields with delayed weeding were recorded up until about 50 days after crop emergence, which corresponds to the heading stage of barley and late flowering stage of rapeseed. The competition between the weeds and the crop started at or shortly after emergence, and the reduction in crop yield was linear with time.

Fertilizers, herbicides, and wild oats. The effects of N, P, barban, AC 84777, and benzoprop on wild oats as well as interactions between the nutrients and herbicides were investigated. The growth of wild oats, measured by the numbers of leaves and tillers and the weights of shoots and roots,

was significantly increased by both N and P. The height of wild oats was significantly increased by P but not by N. All three herbicides significantly reduced the growth of wild oats, as measured by all of the variables recorded. The interactions between herbicides and between P and herbicides were significant for many of the variables. Both N and P increased the growth of wild oats, but the increases were much smaller where the herbicides had been applied.

Soils

Adsorption of atmospheric sulfur gases by bare soils. At 42 sites in central Alberta, the adsorption of atmospheric sulfur gases by four bare soils of varying texture and organic matter, maintained air dry, was from 0.06 to 0.62 kg of S/ha from June to September 1973. The soils were exposed to air but protected from rainfall. When wetted to field capacity at weekly intervals, duplicates of the same soils adsorbed S from 0.23 to 1.67 kg/ha. Wet or dry soil texture had a pronounced effect on the amount of sulfur adsorbed. The two sandy soils adsorbed S at an average of 0.16 kg/ha when dry and 0.41 when wet, the clay loam 0.43 and 0.99, and the silty clay loam 0.48 and 1.52.

Twenty-four of the sites were located in an area (Olds–Calgary) where half of the total industrial sulfur gases are emitted in Alberta. At these sites, the four soils, both wet and dry, adsorbed S at an average of 0.67 kg/ha, whereas the average adsorption of S at 13 of 18 control sites outside this area was only 0.39 kg/ha. At the other five control sites abnormally high levels of sulfate-sulfur were measured in the wet soils but not in the dry. The only factor in common at those five sites was a lichen (unclassified) growth on the wet soils.

OLONETZIC SOIL SUBSTATION, VEGREVILLE

Conservation of the Ap horizon of a Solonetzic soil during deep plowing. Samples of the Ap, Bnt, and Csk soil horizons were taken from a Kavanagh loam Solonetzic soil and used in the greenhouse to determine the value of retaining the Ap horizon on the soil surface during deep plowing. Pots were set up to represent the normal field condition where the Ap horizon overlies the Bnt horizon, which in turn overlies the Csk

horizon. Other greenhouse pots were set up to represent a complete mixing of the horizons such as occurs with present plowing methods, and still others were prepared to represent plowing in which the Ap horizon is retained on the surface over a mixture of the Bnt and Csk horizons. The soils were cropped to barley, under conditions of both adequate moisture and moisture stress. Then they were cropped to alfalfa, and the vegetative growth was measured.

With barley, under adequate moisture conditions, the pots representing the present deep plowing methods yielded 4.82 g/pot, about one-third more than the other treatments. Under conditions of moisture stress, the pots representing field conditions yielded 3.22 g/pot; those representing present plowing methods, 4.71 g/pot; and those representing the conservation of the Ap horizon, 3.69 g/pot.

With alfalfa, under adequate moisture conditions, little difference could be detected between treatments. Under conditions of moisture stress, however, the pots representing natural field conditions yielded 2.29

g/pot; those representing present plowing methods, 3.60 g/pot; and those representing the conservation of the Ap horizon, 3.20 g/pot.

A similar study conducted at the University of Alberta on Duagh silt loam gave about the same results for unfertilized Solonchic soil. However, where fertilizer was used and no moisture stress allowed to develop, there was a greater yield from the soil mixture representing the conservation of the Ap horizon than from the mixture representing present plowing methods. This difference did not occur where moisture stress was allowed to develop.

The conservation of the Ap horizon is usually considered desirable, because it is organic and provides N for plant nutrition. However, barley plants grown on completely mixed horizons contained more N than barley grown with the Ap horizon on the surface, especially under conditions of moisture stress. From a plant nutrition standpoint, special effort to conserve the Ap horizon seems unwarranted unless field trials show a greater benefit than these greenhouse studies.

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Head of Section; Forage and
 livestock production
 Forage and livestock production
 Irrigation
 Dryland crop production

Plant Pathology Section

J. B. LEBEAU, B.Sc., M.S., Ph.D.
 T. G. ATKINSON,⁴ B.S.A., M.Sc., Ph.D.
 F. R. HARPER, B.Sc., M.Sc., Ph.D.
 E. J. HAWN, D.F.C., D.C., B.S.A., M.Sc., Ph.D.
 G. A. NELSON, B.Sc., M.Sc., Ph.D.
 D. W. A. ROBERTS, B.A., Ph.D.

Head of Section; Forage and
 turfgrass diseases
 Cereal diseases
 Disease loss assessment
 Nematode diseases
 Bacterial diseases
 Cryobiology

Plant Science Section

D. B. WILSON, B.Sc., M.S., Ph.D.
 J. R. ALLAN, B.Sc., M.A., Ph.D.
 S. FREYMAN,⁵ B.Sc., M.S.A., Ph.D.
 M. N. GRANT, B.Sc., M.Sc., Ph.D.
 M. R. HANNA, B.S.A., M.S.A., Ph.D.
 A. JOHNSTON, B.S.A., M.S.
 M. S. KALDY, B.Sc., M.Sc., Ph.D.
 G. A. KEMP, B.Sc., Ph.D.
 R. I. LARSON (Miss), B.A., M.A., Ph.D.
 M. D. MACDONALD, B.Sc., Ph.D.
 H. MCKENZIE, B.S.A., M.Sc., Ph.D.
 D. J. MAJOR, B.Sc., M.Sc., Ph.D.
 J. J. SEXSMITH, B.Sc., M.Sc.
 S. SMOLIAK, B.Sc., M.S.
 W. E. TORFASON, B.S.A., M.Sc., Ph.D.
 S. A. WELLS, B.S.A., M.Sc., Ph.D.

Head of Section; Irrigated pastures
 Aquatic plant physiology
 Crop physiology
 Winter wheat breeding
 Forage legume breeding
 Range ecology
 Food science
 Vegetable breeding
 Wheat cytogenetics
 Corn breeding; wheat cytogenetics
 Spring wheat breeding
 Crop physiology
 Crop weeds
 Dryland pastures; grass breeding
 Vegetable culture
 Barley breeding

Soil Science Section

D. C. MACKAY, B.Sc., M.S., Ph.D.
 D. T. ANDERSON,⁶ B.S.A., M.Sc.
 R. G. BELL, B.Sc., Ph.D.
 J. B. BOLE, B.S.A., M.Sc., Ph.D.

Head of Section; Plant nutrition
 Agricultural engineering
 Environmental microbiology
 Plant nutrition

J. M. CAREFOOT, B.S.A., M.S.A.
 J. F. DORMAAR, B.S.A., M.S.A., Ph.D.
 S. DUBETZ, B.Sc., M.S.
 E. H. HOBBS,⁷ B.Sc. (Eng.)
 K. K. KROGMAN, B.Sc., M.Sc.
 L. E. LUTWICK, B.Sc., M.Sc., Ph.D.
 J. L. NEAL, B.Sc., M.S., Ph.D.
 M. OOSTERVELD, B.Sc. (Eng.), M.Sc., Ph.D.
 U. J. PITTMAN, B.Sc.
 A. D. SMITH, B.Sc.
 T. G. SOMMERFELDT, B.Sc., M.S., Ph.D.
 J. C. VAN SCHAIK,⁸ M.Sc., Ph.D.

Chemical analyses
 Organic chemistry
 Irrigation agronomy
 Irrigation engineering
 Irrigation efficiency
 Chemistry and genesis
 Soil microbiology
 Hydrology
 Dryland agronomy
 Dryland forages
 Drainage engineering
 Soil physics

Veterinary-Medical Entomology Section

W. O. HAUFE, B.A., M.Sc., D.I.C., Ph.D.
 K. R. DEPNER, B.Sc., M.Sc., Ph.D.
 M. A. KHAN, G.V.Sc., M.S., Ph.D.
 W. A. NELSON, B.Sc., M.Sc., Ph.D.
 R. H. ROBERTSON, B.A., M.Sc.
 J. A. SHEMANCHUK, C.D., B.Sc., M.Sc.
 J. WEINTRAUB, B.A., M.S.
 P. R. WILKINSON, B.A., M.A., Ph.D.

Head of Section; Bioclimatology
 and behavior
 Black fly ecology
 Toxicology
 Physiology (ectoparasites)
 Serology
 Biting fly ecology
 Cattle grub ecology
 Ecology and control of ticks

Departures

N. B. McLAUGHLIN, B.Sc. (Eng.), M.Sc.
 Transferred April 30, 1974, to Research Station,
 Swift Current, Sask.
 K. C. PIEUK (Mrs.), B.A., M.L.S.
 Transferred January 30, 1974, to Departmental
 Library, Ottawa
 I. L. STEVENSON, B.S.A., M.S.A., Ph.D.
 Transferred July 26, 1974, to Chemistry and
 Biology Research Institute, Ottawa

Forage systems engineering
 Assistant Librarian
 Associate Director

VISITING SCIENTISTS

J. R. ANDERSON, B.S., M.S., Ph.D., 1973-74
 Sabbatical from University of California, Berkeley,
 Calif.
 M. S. R. M. RAO, B.Sc., M.Sc., Ph.D.
 Transfer of work from Soil Con-
 servation Research Centre, Bellary,
 India

Bloodsucking flies
 Water infiltration into
 Solonchic soils

¹On transfer of work to Poultry Research Centre, Edinburgh, Scotland, from July 1973 to June 1974.

²Seconded from the Research Division of the Economics Branch.

³On educational leave, Purdue University, West Lafayette, Indiana, from August 1973 to July 1976.

⁴On transfer of work to Rothamsted Experimental Station, Harpenden, England, from September 1973 to September 1974.

⁵Seconded to Indo-Canadian Dryland Research Project, Hyderabad, India, from December 1973 to December 1975.

⁶Seconded to Indo-Canadian Dryland Research Project, Hyderabad, India, from January 1971 to April 1974.

⁷On transfer of work to Agricultural Research Service Center, Kimberley, Idaho, from March to December 1974.

⁸On transfer of work to University of Arizona, Tucson, Arizona, from December 1973 to March 1974.

INTRODUCTION

The Research Station at Lethbridge has regional and national responsibility for a broad and comprehensive research program in basic and applied science related to agriculture.

The scientists represent a wide range of disciplines and functions, and are integrated into multidisciplinary, mission-oriented program groups. Particular emphasis is placed on the breeding and management of grasses, legumes, cereals, oilseeds, and horticultural and special new crops; nutrition, management, and breeding of beef and dairy cattle and sheep; soil and crop management; resource conservation and erosion control; biological disposal of crop and animal wastes; management of pesticide residues; assessment of crop and animal losses from pests; control of economically important diseases of crops; and control of insect pests of crops and animals. Economists seconded from the Economics Branch are integrated into the research programs to assist in the planning of research and the evaluation of research results, and to facilitate the presentation of this information to the farm community.

As part of Canada's program of aid to developing nations, the Station has collaborated with the Indian Council of Agricultural Research in the establishment and operation of research at 23 locations in India to improve dryland crop production.

During the year, construction began on a new office-laboratory complex to accommodate the staff of the Station, the local offices of the Production and Marketing Branch, and the regional and district offices of Alberta Agriculture. This arrangement will facilitate better communication, coordination of effort, and service to the food industry in southern Alberta.

This report summarizes selected major research results of work done in 1974. More detailed research results can be obtained from the scientists or publications listed in the report. Correspondence or requests for reprints should be directed to: Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews
Director

ANIMAL SCIENCE

Poultry

Wheat for broiler rations. In broiler chick rations containing 23% protein supplemented with lysine, high-protein (19.7%) Neepawa wheat gave similar growth rates to corn and low-protein (13.5%) wheat. In another trial, the utility wheats Pitic 62 and Glenlea gave results equal or superior to corn and Neepawa wheat in supporting growth rate and feed efficiency of broiler chicks when the ration contained at least 20% total protein. In both trials, the use of wheat rather than corn resulted in considerable savings in cost because less soybean meal was required. The saving was greatest with the high-protein Neepawa wheat.

Sheep

Finishing of lambs. Three groups of feeder lambs with initial weights of 18.5, 18.4, and 17.8 kg were fed three different rations. Ration 1 consisted mainly of 70% barley and 27% oats, ration 2 of 70% oats and 27% barley, and ration 3 of 70% hay, 19% barley,

and 8% oats. On the average, lambs fed ration 3 required 74.6 days to reach market weight, but those fed the all-concentrate rations 1 and 2 required 99.1 and 104.6 days ($P < 0.01$). The mean weights of trimmed fat from carcasses of lambs on rations 1, 2, and 3 were 2.65, 2.35, and 1.74 kg ($P < 0.01$). Flavor was affected by the rations. The flavor of chops from lambs fed ration 3 was the most acceptable ($P < 0.05$) to a taste panel.

Longevity of purebred ewes. Mortality rates were similar in flocks of purebred Romnelet, Columbia, Suffolk, and North Country Cheviot ewes in the first 4 yr of life. After 4 yr, the mortality rate increased in the N.C. Cheviot flock and after 6 yr in the Suffolk flock. After 8.5 yr of production, the percentages of ewes remaining in the Romnelet, Columbia, Suffolk, and N.C. Cheviot flocks were 22, 25, 5, and 0. Average total weaned-lamb production per ewe of the foundation flocks was 149.5 kg in Suffolk, 146.6 kg in Romnelet, 119.3 kg in Columbia, and 92.1 kg in N.C. Cheviot.

Beef Cattle

Feeding value of corn silages. Silages made from multistalked (Stewart Multi-G) and single-stalked (Stewart 3502) hybrid corns cut on the same date were similar in contents of dry matter, lactic acid, protein, calcium, and phosphorus, and digestibilities of energy and protein. However, a larger part of the dry matter in the silage from the single-stalked hybrid was contained in the kernel. When these silages were fed ad lib. with steamed rolled barley at 0.5% of body weight to feeder steers, average daily weight gains were the same for both silages (0.79 kg). The two silages did not differ in the conversion of digestible energy consumed to weight gain. These results, together with earlier results from the Station, indicate that silages from multistalked hybrid corns grown in southern Alberta are similar in feeding value to those from single-stalked varieties commonly grown in this area.

Feedlot bloat. Rumen bacteria were found to produce and extrude materials to form an external coat layer composed of acid polysaccharide (*Megasphaera elsdenii*), neutral polysaccharide (*Streptococcus bovis*), proteins (*Bacteroides rumenicola*), or proteoglycans (*Ruminococcus albus*). When carbohydrate availability in the rumen (or in the culture medium) was increased, certain species of rumen bacteria produced very large amounts of this coat material to form a highly viscous slime, which appeared to be very important in the etiology of bloat. In a study of viscosity in the rumen, a strain of *Streptococcus bovis* isolated from the rumen caused no increase in the viscosity (1.5 centipoises (cP)) of a liquid medium when grown on 1% sucrose, whereas it increased the viscosity to 6.8 cP on 3% sucrose and to 112 cP on 8% sucrose. Bloat may result from many different bacteria and involve different types of viscous polysaccharides, proteins, and proteoglycans.

Crossbreeding. An evaluation was completed on 801 calves sired by Red Angus and Beefmaster bulls and born during 1972 and 1973 from 10 different types of crossbred 2-yr-old heifers. Of the heifers, 84% conceived and 70% produced live calves. Of the male calves, 57% were born without assistance, and of the females, 80%. Most of the exotic-cross heifers produced calves that were heavier at birth and weaning than those

produced by the Hereford \times Angus females. Survival to weaning was higher for calves born to the Hereford \times Angus control heifers (94.3%) than for those from the exotic-cross heifers (91.0%). Simmental-sired heifers weaned heavier calves than the Charolais- and Limousin-sired heifers and heifers out of Shorthorn dams weaned heavier calves than those out of Hereford or Angus dams. Progeny from Red Angus bulls were born more easily with less early mortality and a lower incidence of weakness. Also, they weighed 4% less at birth and weaning than those sired by Beefmaster bulls.

Feed restriction. Steer calves that were restricted in feed early, later, or continuously during the feeding period required the same amount of total digestible energy to reach a market weight of 475 kg as full-fed steers. Although restricted steers required more time to reach market weight than full-fed ones, the carcasses from the restricted steers were leaner.

High amylose barley. Steers fed AC38 (high amylose) and Galt (normal amylose) barley gained at the same rate (1.12 and 1.09 kg/day) even though AC38 contained almost twice as much fiber as Galt (11.4 vs. 7.3%). Steers fed Galt barley plus straw to make the fiber content of the ration equal to that of AC38 gained only 0.96 kg/day.

Paunch residue. A diet of up to 80% steam-cooked and dried paunch residue and 20% cubed alfalfa hay was consumed by steers. When the diet contained 90% residue and 10% hay, total feed intake declined from 8.42 to 6.02 kg/head per day and the liveweight gain from 0.42 to -0.10 kg/day. Of the dry matter in the paunch residue, 52% was digestible.

Physiology. A craterlike abnormality of the bovine spermatozoal head was observed under differential interference-contrast microscopy. To date, when this abnormality has occurred in relatively large numbers of the spermatozoa of beef and dairy bulls concurrent inferior semen quality and apparent subfertility have been experienced. Electron microscopy disclosed that this abnormality is a vesicular structure, located between the plasma and outer acrosomal membranes just posterior to the acrosomal apical ridge, and is superimposed on an adjacent nuclear defect.

Urinary calculi. Bulls, early and late castrated steers, and partial castrates (Bairburtjan's method) were maintained under range conditions until 1 yr of age. Some animals were killed then and the others were killed after being fed to a liveweight of 440 kg. All had calculi, and castration treatment did not affect the mean weight of calculous material present. In most animals, the kidneys contained more than the bladder. Urethral lumens were largest in bulls, intermediate in partial castrates, and smallest in steers. Consequently, bulls and partial castrates had an advantage over steers because they could expel calculi more easily rather than because they formed fewer calculi.

Changes in levels of certain blood constituents during fattening of cows. With Hereford and Aberdeen Angus cows fed at a high level of energy intake to produce a high degree of fatness, blood levels of Hb and blood packed cell volume increased ($P < 0.01$) from day 36 to day 94 of the feeding period, but did not change significantly from day 94 to day 136. Plasma total cholesterol levels increased ($P < 0.01$) from day 36 to day 94 and then decreased to day 136, but remained higher at day 136 than at day 36. Whole blood glucose and plasma nonesterified fatty acid levels increased ($P < 0.01$) from day 94 to day 136. Plasma triglyceride levels did not change during the feeding period. Whole blood glucose levels and packed cell volume were higher for Angus than Hereford cows at all three bleeding days, but the difference between breeds was significant ($P < 0.01$) only at day 136.

Rumen microbiology. Of the total digestible energy in the rumen, 4% was used for the production of bacterial slime materials by rumen bacteria. In most cases, cattle will probably not have the enzyme system to digest these complicated polymer slimes, and the energy they contain will be wasted.

Two intracellular polysaccharide granules formed in different bacteria and one bacterial polymer slime have been chemically characterized as glycogen, amylopectin, and dextran. The identification of polymer substances produced by rumen bacteria may help explain the specific enzymatic reversal of viscosity created by these polymers. This should lead to an improved understanding of feedlot bloat and its control.

CROP ENTOMOLOGY

Aphids

Each of 10 insecticides tested was as effective as dimethoate for controlling apterous adults of the pea aphid on alfalfa in greenhouse tests. Four of them failed to control the nymphs, and none prevented reinfestation of the alfalfa 1 wk after application. Pirimicarb was as effective as dimethoate in controlling the nymphs and was less toxic to larvae of a species of green lacewings that is an important predator of the aphids.

As part of a study to determine factors that affect the survival and abundance of predators of aphids, the supercooling points of the ladybird beetle, *Hippodamia quinquesignata* Kirby, were determined at various times during its hibernation. The beetles supercooled to -14.1°C in early fall, to -20.8°C in January, and to -12.5°C in late April. Another predator, the green lacewing, *Chrysopa oculata* Say, was able to complete its larval development at 20°C but not at 15°C .

Cutworms

None of the 11 insecticides tested for control of the pale western cutworm was as toxic to the cutworm as was endrin, but four were more toxic than leptophos. In field tests, however, sprays of leptophos and chlorpyrifos on corn appeared to be more effective than endrin in controlling late-instar larvae of this species.

A sex attractant was discovered for males of the clover cutworm. The attractant is a mixture of two synthetic compounds. The optimum proportions of the compounds and the most effective concentration per trap have been determined in field tests in which about 12,000 males were captured.

A total of 80 potential synthetic attractants, most of which were synthesized here, were tested in traps in the field. About 45 different species of moths were attracted to and captured in the traps.

A diet consisting of beans, yeast, agar, and antibiotics was found to give a high survival (70%) of cutworm larvae and a high rate of pupation to normal adults. Continuous cultures of the pale western, redbacked, army, and darksided cutworms are being reared on this diet for experimental purposes.

Grasshoppers

The intensity of the grasshopper infestation in Alberta continued to increase. Light infestations were forecast for 39 300 km² and moderate infestations for 20 800 km². The severe infestations for 11 300 km² were more than double those forecast for 1974.

Twenty-eight species of grasshoppers and 71 species of Hemiptera, Homoptera, and Coleoptera, mostly plant-feeding species, have now been identified as inhabitants of Alberta rangelands. Heavy grazing decreased the numbers of most species, but increased the numbers of the false chinch bug and two species of grasshoppers, *Melanoplus dawsoni* (Scudder) and *Camnula pellucida* (Scudder).

Eight insecticides were found to be more toxic than dimethoate for control of the clearwinged grasshopper in the laboratory. Carbofuran, although adversely affected by rainfall, was the most effective insecticide in simulated field tests. Chlorpyrifos, methidathion, and dimethoate were slightly less effective than carbofuran.

In a field test, methamidophos and chlorpyrifos equaled insecticides recommended for grasshopper control in a crop of wheat, but against late-instar and adult grasshoppers only carbofuran and chlorpyrifos gave adequate control in headlands. Aircraft application of insecticides was not as effective as ground application in short crops or in headlands. Carbofuran in a bait was better than dimethoate and remained effective for 3 wk when placed in an alfalfa crop infested with grasshoppers.

Pollinators

Two superior strains of the alfalfa leafcutter bee have been selected. One, a hardy strain that had escaped to overwinter in an unheated granary, has now been increased to 45,000 individuals. The other is a univoltine strain that is now 99.6% pure. Both strains increased fivefold in 1974 compared with a twofold increase for the unselected leafcutters.

Tall hives were more attractive to the leafcutters than short hives and those painted with blue letters on a black surface were more attractive than those painted with other symbols and other colors.

Populations of wild bumblebees are increasing in number. Of the hives placed out in the foothills in 1964, 63% were inhabited by bumblebees. The most favored hives were

those placed underground, facing south, on the edges of meadows.

Potato Insects

Colorado potato beetles in the Lethbridge area no longer show resistance to DDT. The beetles had a 10-fold resistance in 1967 before the use of this insecticide stopped. Soil applications of Counter (Cyanamid of Canada) and Bay 92114 (Chemagro Limited) appeared to give systemic protection against the beetle and its larvae.

Four insecticides gave good protection of potatoes against the prairie grain wireworm when applied in the furrow at planting. Two of them, Counter and fonofos, also gave good protection against the wireworms when applied as side-dressings 3 and 5 wk after planting.

Rape Insects

Flea beetles, mostly *Phyllotreta cruciferae* (Goeze), were the main pests of rape in 1974. Granular carbofuran applied with the seed reduced the densities of the beetles by 55% for 30 days and increased yields by 54% over those from the untreated plots. Carbofuran as a spray to the seedling crop appreciably reduced the numbers of beetles for only 4 days and increased yields by 20%.

Rape Residues

An aqueous extract of the phytotoxin from rape plants has been separated into three fractions. One fraction contains common amino acids and several sulfur amino acid antagonists.

Sugarbeet Insects

A sex attractant for males of the beet webworm and four synergists for the attractant have been discovered. The initial discovery, made by laboratory bioassay, was confirmed by field tests in which about 4000 males were caught in traps baited with the attractant.

Temporary registration has been obtained for azinphos-methyl at 140 g/ha for control of flea beetles on sugar beets on the basis of the absence of insecticide residues in the roots and foliage.

Larvae of the sugarbeet root maggot developed more resistance to freezing when they were reared under dry soil conditions than under moist soil conditions.

The insecticide heptachlor applied in the furrow at seeding appeared to reduce the biological score of the amino acids of the kernels.

Dimethoate is currently restricted to application to wheat not less than 21 days before harvest. Data indicate that this restriction can be reduced to 14 days. Dimethoate applied at 0.28 and 0.56 kg/ha had decreased to 0.01 and 0.02 ppm in the kernels 13 days after application, but appreciable residues (1.97 and 8.45 ppm) were still present on the chaff.

Malathion residues on the outside leaves of lettuce decreased from 16.2 ppm immediately after treatment to 0.06 in 7 days and 0.01 in 14 days.

In a study related to the control of black flies in the Athabasca River, before insecticide treatment, the fat of fish from the river was found to contain averages of up to 0.67 ppm polychlorinated biphenyls and 3.44 ppm unidentified hydrocarbons. In addition, some species averaged 0.14 ppm α BHC and 0.02 ppm heptachlor epoxide. Traces of the DDT complex were also present.

Preliminary results showed that 21 days after treatment of the river with methoxychlor fat of suckers contained 0.79 ppm of methoxychlor. Concentrations of methoxychlor residues differed between species.

Wheat Stem Sawfly

Increases in sawfly damage were noticeable, particularly in the Bindloss to Acadia Valley area. A study of the population dynamics of the sawfly along with a long-term study of the resistant wheat Rescue showed that resistant varieties offer adequate protection against sawfly damage. However, growing these varieties is unlikely to reduce the hazard of sawfly infestations in succeeding years.

Miscellaneous Pests

The strawberry root weevil, a household pest, can be readily controlled by contact sprays of propoxur. Dimethoate, malathion, and chlordane were less effective, but were better than DDT, carbaryl, or methoxychlor.

Simulation Models for Farm Business Planning

A simulation model for alternative beef-forage production systems has been developed. The beef production alternatives that it contains range from cow-calf to cow-calf-finishing. Production technology options include natural and artificial insemination breeding, alternative types of shelter, and several combinations of pasture, stored forage, and grain feeding for cows and feeders. Pasture sources in the model include native, improved, cereals, and crop residues. Pasture improvement alternatives and alternative seasonal utilization patterns for each pasture type are also involved. A crop simulation model has also been developed. It contains all of the major cereal and oilseed crops produced in the prairie region and the technology alternatives for these crops.

Both models employ data and production technologies applicable to the Brown soil zone of Alberta and Saskatchewan. These models will be integrated into a comprehensive crop-livestock model, which can then be adapted to other soil and climatic regions. The models are being used in agricultural policy analysis and in evaluation of research results.

Derivation and Evaluation of Rations for Feeder Cattle

Data from feeding trials at several research stations have been used for a linear programming model that simultaneously selects feeding programs and diets to maximize net returns for a given set of prices for feedstuffs and slaughter steers. A matrix generator has been developed to facilitate routine use of the model for extension purposes and for its revision and expansion on the basis of new research findings. The model has been used to formulate rations for several sets of feedstuff prices. These rations are being tested in feeding trials.

Economics of Sheep Production

A simulation model has been developed for sheep production. Management alternatives range from traditional, range-based, single-lamb crop systems to intensive, confined, multiple-lambing systems. The model is based on research data from a large number of studies on breeding, nutrition, and

management. With the model, the influence on productivity of a large number of factors can be examined. These factors include lambing schedules, conception, lambing, and mortality rates, rations, types of facilities, and input and product price levels. The model is being used to examine the economics of crossbreeding and to evaluate new methods of intensive sheep production.

Economics of Producing Irrigated Cash Crops

Irrigated farms in the major irrigation districts of Alberta were surveyed. Information obtained in the survey included resource supplies, enterprise mix, and other characteristics of irrigated farms, crop rotations and irrigation methods used, crop yields, and application rates for fertilizer, water, and other inputs.

A linear programming model developed earlier for selection of optimal combinations of crops and levels of N, P, and water has been expanded to include the main irrigated cash crops, alternative irrigation systems, and the specialized machines required for specific crops.

PLANT PATHOLOGY AND PHYSIOLOGY

Forage and Turf Diseases

From evidence obtained in the past 5 yr, we have concluded that the pin nematode, *Paratylenchus projectus* Jenkins, is not the chief cause of alfalfa sickness in central and northern Alberta. We now suspect that *Phytophthora megasperma* Drechs. is the incitant of the disease.

Alfalfa synthetics LN-X and LN-V were shown to be highly resistant to the stem nematode, *Ditylenchus dipsaci* (Kühn) Filipjev, in greenhouse tests. The synthetic LN-X was licensed under the name Trek by the Plant Products Division.

Applying borax to the soil has not controlled winter crown rot of alfalfa effectively, but foliar sprays have been successful. From field experiments, we have found that the borate ion is translocated to the infection site after foliar sprays with borax.

Banff, a dwarf variety of Kentucky bluegrass, was licensed in February 1974. It was developed for lawns and athletic fields and is

resistant to snow mold and other important turfgrass diseases.

Cereal Diseases

The relationship between yield and percentage survival was linear for winter wheat inoculated with the winter crown rot pathogen on dry and irrigated land. The Russian variety Bezostaja showed resistance to the disease for the second successive year.

Cold Hardening of Wheat

The "high molecular weight" form of invertase that accumulates in the leaves of cold-hardy wheat varieties as they develop cold resistance is not covalently bonded to the high molecular weight carbohydrate fraction present in these leaves. In the presence of sodium chloride, the high molecular weight form of invertase disaggregated into smaller, enzymatically active particles that reaggregated in the absence of both salt and the carbohydrate fraction.

Potato Diseases

Freshly cut potato seed pieces held in the greenhouse in saturated soil for 2 days and then transferred to soil at normal moisture levels for 2 wk decayed very little. Seed pieces held for 3 days in saturated soil or seed pieces precut for 12 h decayed severely within 2 wk when transferred to soil with normal moisture.

Cultures of *Pythium* spp. were isolated from precut seed pieces 24 h after planting in the greenhouse. These isolates were extremely pathogenic on freshly cut seed pieces in soil at normal moisture content and at temperatures of 15, 20, and 25°C.

Crop Loss Assessment

Powdery mildew on soft white spring wheat. Powdery mildew can be a significant factor in the yield of soft, white spring wheat, which is grown under irrigation on more than 40 000 ha in southern Alberta. A field test on irrigated land has shown that, on the basis of leaf ratings, the recently introduced semi-dwarf cultivar Springfield is more heavily attacked by mildew than is the other currently recommended cultivar, Lemhi 62. However, Springfield outyielded Lemhi 62 (3.8 vs. 3.6 t/ha; 54 vs. 57 bu/ac). A combined seed treatment and foliar spray program with the experimental fungicide ethirimol reduced the mildew ratings of both

cultivars and increased the yield of Springfield by 0.8 t/ha (12 bu/ac). The yield of Lemhi 62 was not appreciably improved by the fungicide.

Barley diseases. Common root rot, caused by *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur and *Fusarium* spp., has been the most widespread and serious barley disease in southern and central Alberta each year since 1971. Total annual yield for the region was reduced by 6.0–13.8%. The most important leaf diseases were scald, caused by *Rhynchosporium secalis* (Oud.) Davis, and net blotch, caused by *Pyrenophora teres* (Died.) Drechs., which reduced annual yield by 1.1–4.6% and 0.5–2.7%. The barley smuts, caused by *Ustilago nuda* (Jens.) Rostr., *U. nigra* Tapke, and *U. hordei* (Pers.) Lagerh., were responsible for annual yield losses of 0.2 to 0.6%.

Rape diseases. A survey of commercial fields of rape, *Brassica campestris* L., in southern Alberta showed that white rust, incited by *Albugo cruciferarum* S. F. Gray, was the most prevalent disease. In 1974, the yield loss from the staghead phase of the disease was estimated as 2.0% from a yield loss equation.

The key to the growth stages of rape, *B. campestris* and *B. napus* L., was revised and has been accepted as the standard by FAO.

PLANT SCIENCE

Cereals

Barley. During recent years, resistance to barley scald has been transferred by backcrossing to Betzes, Galt, and a strain of the Station designated TR 501 from the agronomically inferior Rivale, Osiris, and Turk respectively. In yield trials, each derived strain has been very similar in agronomic performance to the recurrent parent. The derived strains are being used to measure the losses resulting from scald infection under controlled conditions and in the field. These resistant strains are also being used as parents in the regular breeding program to produce higher yielding two-rowed barley varieties.

Performance of Russian winter wheats. Yields and 1000-kernel weights of winter wheat varieties were lower than normal because of an unusually hot and dry period

in June. Winalta yielded only 1.7 t/ha. Quite unexpectedly, the newer Russian varieties Kavkaz and Aurora were not adversely affected by the unusual weather pattern and yielded 2.8 and 2.7 t/ha, with excellent 1000-kernel weights. Although their low level of winterhardiness precludes their commercial use in Western Canada, these varieties may be extremely useful to winter wheat breeding programs.

Population shifts in spring wheat mixtures. An artificial mixture, composed of equal proportions of six cultivars of spring wheat, exhibited different population shifts when grown in three different environments for 6- and 7-yr periods. The three environments included a nonirrigated regime, an irrigated regime, and exposure to infestation by the wheat stem sawfly.

With one exception, survival of cultivars in the mixtures was related to yield performance in pure cultures under both the irrigated and nonirrigated regimes. The exception was under irrigation where the highest yielder in pure cultures declined slowly in the mixture.

Population shift was somewhat more pronounced in the mixture that was exposed to sawflies. After 7 yr, the two resistant cultivars predominated and three susceptible ones had almost disappeared. The sixth cultivar, a late susceptible one, survived because it had partially escaped infestation due to late maturity.

Wheat cytogenetics. Lines with disomic substitutions of chromosomes from *Agropyron elongatum* ($2n = 70$) for chromosomes 4D, 5D, and 6D of Rescue were evaluated for winterhardiness and seed production after vernalization and hardening treatments. Line 6D produced more kernels per head than the other lines and Rescue. Line 4D was less winter-hardy than lines 5D, 6D, and Rescue.

A monosomic series in Winalta winter wheat for all 21 chromosomes has been produced. Winalta monosomic for chromosome 6D has been crossed with Rescue-A. *elongatum* 6D with a view to producing a disomic chromosome substitution for 6D in winter wheat. This substitution line has the potential to be a high-yielding, winter-hardy forage or utility wheat that is resistant to the wheat curl mite, *Aceria tulipae* (Keifer), the vector of wheat streak mosaic virus.

The cytogenetic basis of resistance to *A. tulipae* resulting when chromosome 6D of

Rescue is replaced by a pair of chromosomes from *A. elongatum* has been further elaborated. The *Agropyron* chromosome was fully effective both as a disomic substitution for chromosome 6D of Cadet and as a disomic addition in Rescue. In contrast, Rescue and Cadet nullisomic for 6D were more susceptible to the mite than the parental varieties. These results show that resistance is due to the *Agropyron* chromosome, and not to deficiencies caused by the absence of chromosome 6D. There is no evidence of interaction between the wheat genotype and the *Agropyron* chromosome in determining resistance to the mite.

Corn

Population densities in corn. Yields of corn silage increased for both a multistalked and a single-stalked hybrid as population density was increased from 35 000 to 115 000 plants/ha. The contribution of tillers to silage yield decreased as population density increased, but the percentage of grain in the multistalked hybrid was higher at 69 000 than at 35 000 or 115 000 plants/ha. The single-stalked hybrid grown at 69 000 plants/ha produced about the same total silage yield as the multistalked hybrid, but the silage contained more grain.

Forage

Trek alfalfa. Trek, a new cultivar of *Medicago sativa* L., was licensed for sale in Canada. It is the first Canadian cultivar that combines resistance to the alfalfa stem nematode with winterhardiness and resistance to bacterial wilt disease. Trek has excellent regrowth after cutting. It should be well adapted to the irrigated districts of southern Alberta for production of hay or dehydrated alfalfa under intensive three-cutting management schedules. Certified seed of Trek should be available beginning in 1977.

Legumes for pasture. An experiment with ewes and lambs grazing on sainfoin, alfalfa, and cicer milkvetch pastures was completed after 5 yr. The trial, conducted on a subirrigated site, compared the productivity and persistence of the three legumes grown alone or in a mixture with crested wheatgrass. The sheep had free choice of the legumes and mixtures under a four-field rotational grazing system. Average yield of forage was highest for sainfoin alone (7.5 t/ha), followed by

alfalfa alone (7.0 t/ha), alfalfa with crested wheatgrass (6.9 t/ha), and sainfoin with crested wheatgrass (6.3 t/ha). Cicer milkvetch yielded 4.3 t/ha alone and 5.2 t/ha with crested wheatgrass. All three legumes were satisfactorily palatable and persistent.

Studies of grazing sheep. *Stipa-Bouteloua* prairie was grazed by sheep at three stocking rates over a 19-yr period. Under continuous heavy grazing (1.7 ha/animal unit month (AUM)), the vegetative cover and forage yield deteriorated mainly because the low-growing blue grama, *Bouteloua gracilis* (HBK.) Lag., increased and the more productive grasses decreased. The mature ewes on the heavily grazed area were lighter and gave birth to smaller lambs, which were lighter at weaning, than those grazed at the moderate (2.0 ha/AUM) or light (2.5 ha/AUM) intensities. The *Stipa-Bouteloua* prairie should not be stocked more heavily than 2.0 ha/AUM to maintain the vegetative cover in a productive condition and sheep production at a satisfactory level.

Horticulture

Limelight green-shell bean. Green seed color was introduced into the green-shell bean Limelight, which was developed here as an early maturing alternative to the lima bean. The green color of the seed coat and cotyledon is much more attractive than the white color of the standard Limelight. The seed color is similar to that common in peas and recently introduced into the lima bean. Green Limelight is expected to be more acceptable as either a frozen or canned processed product. Seed supplies are limited and samples for field trials will not be available until 1976.

Browning of parsnips. Postharvest browning of parsnips was studied with three cultivars grown in three different soil types in southern Alberta. All the cultivars, All American, Harris Model, and Hollow Crown, browned when stored in a Filacell unit at 1°C and 95–97% relative humidity (RH), but the degree of browning varied with soil type and with length of storage. Parsnips grown in a sandy loam soil (63% sand) browned the most, and those grown in a loam soil (45% sand) the least. Most of the browning occurred in the first 3 mo of storage.

Regional potato trials. Potato seedling lines and cultivars from the potato program at the Research Station, Fredericton, and from other Canadian and American stations were evaluated for quality and adaptability to production under irrigation. From 130 entries, about 20 preliminary selections were considered worthy of advanced testing. In an advanced trial, 10 of 15 lines yielded more and had higher dry matter than Netted Gem. All six seedling lines selected for chipping produced commercially acceptable chips and two of these produced exceptionally light-colored chips. Two others produced significantly higher yields than Norchip. Two seedlings, FS 6339 and F 62012, which are being proposed for introduction by the Prairie Potato Council, were grown in block trials and outyielded standard cultivars.

Weeds

Weed control in snap beans. In a test of preplanting, incorporated applications of individual herbicides and herbicide combinations, the best results were obtained by using trifluralin at 1.12 kg/ha or fluchloralin at 1.40 kg/ha. After treatment with either of these herbicides, marketable pod yields of Moongold snap beans were 65% higher and green weight of weeds 85% lower than in untreated plots that had been cultivated once. The weed infestation consisted of a mixture of green and redroot pigweeds, lamb's-quarters, and stinkweed (135 plants/m²), and green foxtail (30 plants/m²). Pigweeds comprised about 75% of the total stand of broad-leaved weeds. Dinitramine gave about the same degree of weed control as trifluralin or fluchloralin, but pod yields were no higher than in the untreated checks. In another test of combinations of preplanting and preemergence treatments none gave any better results than those obtained from the best preplanting treatments.

Aquatic plant management. Phosphate levels were studied in Wascana Lake, Saskatchewan, after total lake treatment with herbicides in 1972 to control excessive growth of macrophytes. The water was sampled every 2 wk for the summers of 1969-72 and every 2 wk for the entire year in 1973 and 1974. In 1971, the entire lake was treated with various dosages of a 1:1 mixture of diquat and paraquat injected underwater to control all native submergent

macrophytes. Immediately after the treatment in 1971, total phosphate increased by 83%, but in 1972 and 1973 the values decreased to levels that were 82% and 60% below the pretreatment (1969-70) levels. Preliminary studies in the greenhouse suggest that this decrease may be related to the ability of rooted submergent plants to recycle nutrients from the submerged soil to the water.

Organic total solids showed a marked, continued increase mainly because of an increased algal population. Phytoplankton populations have largely replaced the filamentous algal populations in the lake, but no new phytoplankton species have appeared. The phytoplankton "blooms" have become denser and have longer cycles; for example, bloom of *Aphanizomenon* extends late into the fall.

SOIL SCIENCE

Soil-Plant Relations

Rhizosphere studies of wheat. Microorganisms capable of nonsymbiotic fixation of nitrogen, as measured by the acetylene-ethylene reduction technique, have been found in the rhizosphere soil of a homeologous substitution line of Cadet-Rescue 5D wheat. The microorganisms were successfully isolated in pure culture and appear to be an anaerogenic strain of *Bacillus polymyxa*.

Uptake of ³HHO and ³²P by roots. Uptake of ³HHO and ³²P from soil by individual roots of wheat and rape, *Brassica napus* L., plants was measured directly at several stages of maturity and from various depths in the soil. Although the soil was uniform in temperature, bulk density, and composition, larger amounts of both nutrients were taken up by surface roots (within 15 cm of the surface) than by roots deeper in the soil. Uptake of ³HHO per unit length of root increased with age, whereas uptake of ³²P decreased to below detection limits by 45 days after germination. Wheat roots were more efficient than rape roots in absorbing ³HHO, but rape roots took up larger amounts of ³²P per unit length of root. The uptake of native or added P from soil below 30 cm was minimal with these annual crops because the main demand for this nutrient occurred at early growth stages when their root systems were restricted to the surface layers.

Biomagnetism. Magnetic treatment may increase the longevity of some seeds and be a useful way of preserving the viability of scarce or valuable species. Magnetically treated Red Mexican beans, which were stored in sealed jars for 11 yr, produced more growth (18.4 vs. 11.3 mm) and germinated better (79 vs. 44%) in a 48-hr germination test than untreated beans stored for the same period. Similarly, magnetically treated Compapa barley after 11 yr of storage produced about 80% more growth (47.4 vs. 26.0 mm) and germinated better (64 vs. 34%) than untreated stored seed.

Response of three grass species to N fertilizer. Nitrogen fertilizer, as ammonium nitrate at the rate of 165 kg N/ha, increased the yields of hay from 2-yr-old stands of brome-grass, crested wheatgrass, and Russian wild ryegrass in the thin Black soil zone by 4.6, 4.4, and 1.9 t/ha at one site and by 3.8, 5.7, and 2.1 t/ha at another site. In the Dark Brown soil zone, the increases were 7.5, 7.1, and 3.0 t/ha at one site, but at a drier site they were only 1.5, 2.8, and 2.1 t/ha.

Rapeseed culture. Conventional seeding rates used for rape production may be higher than necessary. In 2 of 3 yr, Span rape grown on dryland has yielded as much when seeded at 2.24 kg/ha as when seeded at 4.48 kg/ha, if flea beetle infestations were controlled throughout the growing season. Adequate control of flea beetles was obtained from granular carbofuran applied with the seed. When the rate of seeding was reduced below 4.48 kg/ha, flowering tended to be later and maturity was delayed.

Conservation

Reclaiming eroded dryland soils. Moderate (8 cm or less soil loss), severe (15 cm or more loss), and very severe (30 cm or more loss) erosion of soil (Lethbridge loam) reduced the average yields from four cycles of a dryland spring wheat and fallow rotation to 89, 63, and 44% of the yield (1.9 t/ha) from the unfertilized, noneroded plots. Fertilizer (40-35-0) partly offset the effects of erosion, and average yields (four crop cycles) for the three soil erosion treatments were 100, 90, and 74% of control yields. In the fourth rotation cycle, yields on the fertilized, eroded soils approached those of the control. Repeated applications of fertilizer increased significantly the $\text{NO}_3\text{-N}$, total N, and organic matter (OM) in the soil, but did not increase

the available P. Similar changes were not detected on the unfertilized, eroded soils. Thus, continued use of fertilizer is essential on eroded soils, but restoration of fertility is a slow process.

Comparison of barnyard manure, fertilizer, and crop residues. Application of manure at 27 t/ha every 4 yr in a four-course rotation (soft spring wheat, sweet corn, sugar beets, and sugar beets) increased the OM, N, P, and K of the soil after four cycles. In the last cycle, the yield of first-year sugar beets was increased 31% (42.8 vs. 32.7 t/ha) with manure. When 66 kg N/ha were combined with the manure, the yield of first-year sugar beets was increased 53%. The response by second-year sugar beets was smaller. The yield of sweet corn was increased 11% with manure and 28% with manure and fertilizer, but the yield of wheat was unaffected. The effects of incorporating sugar beet tops or corn stovers into the soil were less pronounced than those of the fertility treatments and took longer to become apparent. For the 16-yr period, the average accumulative value of 1 t of manure in terms of increased beet yields was about \$8 or, at 1974 prices, about \$22.

Use of feedlot manure. Manure from cattle feedlots can be used profitably by applying it to the land. In the greenhouse, yields of wheat grown on Cavendish fine sandy loam and on Lethbridge loam that had been manured at rates of 67, 134, and 268 t/ha exceeded those where only fertilizer (N at 44.8 and P at 39.2 kg/ha) was used. The greatest yields were usually obtained from the highest rate of application of manure. These yields exceeded those from the treatment with 67 t/ha by as much as 50% in some instances. Yields were even higher when both manure and fertilizer were used. The soluble salt, Na, and Ca + Mg contents of the soil increased with increasing rates of manure application. However, in a field where manure had been applied annually at 70 t/ha for over 40 yr, there was no undesirable buildup of N or P and the salt content of the soil was less than that of an adjacent nonmanured and unfertilized field. Based on results obtained from a long-term rotation containing sugar beets and using 1974 prices, manure can be transported to and spread on land 24 km (15 miles) away from the feedlot and still be a more profitable investment than commercial fertilizer.

Fecal coliform bacteria on alfalfa irrigated with sewage effluent. All fecal coliform bacteria that were present on alfalfa at about 1500/g dry matter immediately after irrigation were destroyed after exposure to bright sunlight for 10 h at temperatures above 11°C. Little decrease in numbers was observed during cool (below 10°C), damp, overcast conditions. These results suggest that the potentially infectious *Salmonella* spp., which have similar survival characteristics, would also be killed under these conditions. Therefore, to protect livestock from possible salmonellosis, alfalfa irrigated with sewage effluent should be exposed to a minimum of 20 h bright sunlight at temperatures above 11°C before livestock are permitted to eat it. This recommendation applies only to alfalfa in the prairie region. The different anatomical structure of grass species, particularly the presence of the leaf sheath, could result in markedly different results.

Irrigation

Leaching requirements. A computer model of water movement and chemical reactions in irrigated soils predicted that irrigation in excess of crop requirements is not required to prevent objectionable salt accumulation. Irrigation with quantities equal to evapotranspiration will result in salt accumulation at a level about 140 cm below the soil surface when the water table is maintained at 180 cm. When applications that are 10% above crop moisture requirements are used salts will be leached out of the profile, but a salt buildup at 140 cm will not be prevented. Varying the interval between irrigations from 5 to 21 days does not influence the salt distribution in the root zone. When irrigation is less than crop requirements, water and salt will move upward and cause salinity in the root zone.

Interpretation of precipitation records. Distribution of precipitation at Lethbridge is very skewed, especially during the growing season. Precipitation for May averaged 54 mm (2.12 in.) over 73 yr, but was below the mean in 67% of the years. For the period April through July, the mean is 204 mm (8.02 in.) with 61% of all values less than the mean. For forecasting or planning farming operations, the median and mode are better indicators than the mean for predicting rainfall in a particular year. Their values are

always lower than the mean; for May the median is 44 mm and the mode 30 mm. The standard deviation has little meaning for describing the precipitation distribution because of the skewness.

Response of corn to irrigation and fertilizer. Without irrigation, the yield of fresh green silage corn was 21.3 t/ha on a sandy loam soil with an initial NO₃-N content of 84 ppm and there was no response to N fertilizer. Where soil moisture suction at a 30-cm depth was kept below 0.5 bar by irrigation until tasseling, the average yield was 48.4 t/ha and there was no response to fertilizer. In contrast, where irrigation was continued until 2 wk before harvest, the yields were 66.8, 62.1, 67.5, and 70.0 t/ha where 0, 84, 168, and 252 kg N/ha were applied.

At the same location, yields of grain corn (15% moisture) were 2.5 and 2.7 t/ha where irrigation was continued until tasseling and until 2 wk before harvest. Without irrigation, only about 0.6 t/ha were produced. Yields were not increased by N fertilizer.

Soil Properties

Soil enzymes. The activities of dehydrogenase, phosphatase, arylsulfatase, invertase, amylase, and cellulase were greater in soil from overgrazed than ungrazed sites at two locations. Activity of soil enzymes was highest in soil collected during the winter months when frozen. Activity of the soil enzyme dehydrogenase was significantly decreased by NO₃-N concentrations above 10 μ mol/g soil.

Decomposition of soil organic matter. Organic matter of the Brown Chernozemic soils was more readily decomposed than that from the Dark Brown and Black Chernozemic soils during incubation in the laboratory. Between 80.4 and 91.4% of ¹⁴C added in the form of glucose was liberated as ¹⁴CO₂ in the Brown and Dark Brown Chernozemic soils, and between 20 and 35% of the remaining ¹⁴C was extractable with Chelex-100. In the Black soils, only 50% of the added ¹⁴C was liberated and only 8% of the remaining ¹⁴C was extractable. Raw roots of the main species that contributed to the organic matter of these soils were *Festuca scabrella* Torr. (Black soils), *Stipa spartea* var. *curtiseta* Hitchc. (Dark Brown soils), and *Stipa comata* Trin. & Rupr. (Brown soils). These roots had C:N ratios of 35:1, 22:1, and 18:1. The loss of carbon during incubation of these roots

for 47 wk was inversely related to the C:N ratios. The highest amino acid content in the raw roots was associated with the greatest carbohydrate loss and least lignin loss.

Paleosol studies. Such criteria as water droplet penetration, magnetic susceptibility, and content of well-crystallized Fe oxides indicated that some of the paleosols along the upper North Saskatchewan River valley were affected by fire before burial. The horizons that contained charcoal and partially burned peat also repelled water. Therefore, they only reached temperatures between 200 and 400°C. Other fire-affected horizons, which contained no charcoal, were reddish brown, had high magnetic susceptibilities and high contents of well-crystallized Fe oxides, but did not repel water. These reddish brown horizons had reached temperatures higher than 400°C, but differential thermal analysis indicated that they had not reached temperatures over 600°C.

Clay-organic complexes. Infrared spectra (IR) and derivative thermograms (DTG) indicated that the clay-organic complexes and the humic acids of the Black soils were more highly oxidized, more aromatic, and more resistant to thermal decomposition than those of the Brown soils; the OM of the Dark Brown soils was intermediate. The root lignins from the same soils showed many of the same zonal variations in IR and DTG properties as the soil OM. These relationships indicated that the OM of the Chernozemic soils assumes some of its character directly from the roots of the grasses occurring on these soils. This implies a changing reference point, which must be taken into account when comparing differences in humification of OM in the zonal sequence of Chernozemic soils.

VETERINARY-MEDICAL ENTOMOLOGY

Biting Flies

Mosquitoes. The discovery of the complete life cycle of the fungal parasite *Coelomomyces psorophorae* Couch has greatly enhanced the possibility for practical biological control of mosquitoes. The copepod *Cyclops vernalis* Fischer, the intermediate host for the fungal parasite, is infected by monoflagellate spores from the resistant sporangia of *C. psorophorae*. Then biflagellate spores from *C. vernalis*

infect mosquito larvae and produce resistant spores to complete the cycle. The pathogen can now be mass-produced under laboratory conditions to explore its effectiveness in the biological control of various pest species of mosquito.

Laboratory experiments with juvenile hormone analogues, Altosid and PH-60-40 (Thompson-Hayward Co.), have shown that both are effective in disrupting the metamorphosis of mosquito larvae at a concentration of 0.01 ppm in water at pH 7.4 and a temperature of 19°C.

Black flies. Of *Simulium arcticum* Malloch females attacking cattle in June, 45% were parasitized by an unidentified nematode. Parasitism apparently does not interfere with bloodfeeding behavior or with ability to seek hosts in long flights from breeding sites.

Immature stages of *S. venustum* Say and *S. vittatum* Zetterstedt in small streams are frequently infected by a fungal pathogen, *Entomophthora culicis* A. Braun. An unidentified, ciliated, protozoan parasite infects the ovaries of *S. arcticum* and completely destroys the follicles. Both pathogens deserve further detailed study as potential biological control agents for black flies.

Parity profiles for *S. arcticum* indicated three oviposition cycles during the spring, summer, and autumn seasons, but no autogenous cycle in spring. Females produced an average of 198 viable eggs on one blood meal in 110 h under laboratory conditions.

Partially darkened shelters in pasture fields provided some relief for cattle from the attack of biting flies during heavy outbreaks. During the peak of infestation, sheltered steers outgained unprotected ones (0.74 vs. 0.39 kg/head per day) but for the summer grazing period the corresponding difference (0.63 vs. 0.59 kg/head per day) was not statistically significant.

Population studies on *S. arcticum* were started on a 160-km stretch of the Athabasca River. Before pesticidal treatment in May, larval numbers reached 4468/cone compared with the peak of 769 during the whole season in 1973. Records, including preliminary studies in previous years, suggest that one or two outbreaks occur in every 3 yr. Density of adults flying above the river surface in June was limited to 13/sweep km compared with 122 in 1973 and with 485 and 745 in the outbreak years of 1971 and 1972.

Environmental management in chemical control. Monitoring systems for nontarget organisms in experimental chemical control of black flies in river systems were improved and expanded. In particular, improvements in sampling methods have increased the representation of the invertebrate fauna from 35 genera in 27 families to more than 90 genera in more than 50 families. Within food chains that include fish, indicator species can now be selected with a high level of confidence for a standardized procedure to monitor regular abatement programs.

Warble Flies

Sterilization. Unsatisfactory survival of γ -irradiated puparia in field plots was improved by supplementing laboratory rearing with field incubation. Sterile adults were synchronized in their development to emerge at the same time as field-reared normal flies. Optimal irradiation for sterility of *Hypoderma lineatum* (de Villers) was 4 krad; that for *H. bovis* (Linnaeus) was between 5 and 6 krad with sterility averaging 98%.

Technical prerequisites are nearly completed for a field trial of the sterile male method to eradicate cattle grubs. These have included preliminary reduction of infestation by chemicals on a large cooperating ranch, identification of sources of fly production and related mating sites, and increased production of grubs for mass release of sterile males.

Host-Parasite Relations

Resistance of cattle to grubs. Controlled rates of infestation have shown major differences in the development of resistance of *H. lineatum* within populations of cattle. In innately susceptible cattle, 77% of grubs survived in the first infestation, whereas only 12% survived in the next four infestations. For innately resistant animals, the equivalent values were 6 and 3%. An intermediate group maintained an average grub survival rate of 19% (13–26%) during the first four infestations with a drop to 6% in the fifth.

Vitamin A in host resistance. The role of vitamin A is not consistent in host-parasite systems. Controlled experiments with vitamin-deficient mice showed no beneficial effects of vitamin A supplementation on resistance to the louse *Polyplax serrata*

(Burmeister). This is in contrast with vitamin-deficient sheep in which vitamin A supplementation enhanced resistance to the sheep ked.

Serology. A technique of using injections of sympathetic and parasympathetic drugs to stimulate salivary secretions in maximizing material for serological analyses has been successful with ticks. Pilocarpine produced the highest frequency of response, but adrenalin produced the largest secretions. The drugs were less effective in stimulating tabanids.

Synanthropic Flies in Cattle Feedlots

Biological control. Imported parasites *Spalangia endius* Walker and *Muscidifurax raptor* G. & S. in combination with sanitation of manure packs and pesticidal bait stations for adult house flies reduced fly production from feedlots by 75 to 95%. *M. raptor* successfully overwintered in feedlots. Optimal host-parasite ratio was 20:1. At ratios between 1:1 and 8:1 intraspecific competition reduced parasite production. *M. raptor* was more efficient than *S. endius* at low densities of host puparia.

Recycling of animal waste. Cattle feedlot manure produced dry pupal weights of house flies almost equal to amounts reported for poultry manure when seeded with 5000 eggs per 3.36-kg (8-lb) unit. At rates up to 15 000 eggs/unit, pupal production decreased in contrast with optimum production in poultry manure. Reduction of cattle manure was more rapid and thorough at the higher egg densities.

Chemical Control

Cattle lice. Pour-on treatments with fenitrothion at 10 mg/kg effectively controlled the shortnosed cattle louse. Treatments in either spring or autumn provided protection for about 6 mo.

Black flies. Methoxychlor injected into the Athabasca River at the rate of 0.3 ppm for 15 min on June 4 reduced larval populations of *S. arcticum* by 99.9% in a 160-km section monitored immediately downstream. Repopulation reached a high of about 5% of original density in July, but declined throughout the remainder of the summer.

Warble extermination. Programs were continued with chemicals in Alberta and Saskatchewan. The infestation level in monitored groups of untreated yearlings in Wetaskiwin County was 1.6 grubs/head and in the District of Maple Creek it was 3.2. The baseline levels at the beginning of the program were 9 and 20.

Ticks. Tick paralysis in cattle was a serious problem in the interior of British Columbia in 1973. A review of control procedures suggested that the cause was a departure by some ranchers from the recommended timing of chemical treatments rather than reduced efficacy of pesticides.

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Research Station Agassiz, British Columbia

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Departure

M. K. JOHN, B.Sc. (Agr.), M.Sc., Ph.D.	Soil chemistry; soil fertility
Transferred to Department of the Environment, Ottawa, August 1974	

INTRODUCTION

During 1974 internal research activities were organized into two sections, Animal Science and Crop Science, in order to increase coordination. Dr. L. J. Fisher transferred from the Animal Research Institute in Ottawa to undertake research at this Station on the mineral nutrition of dairy cattle.

Two highlights of research in 1974 include the release of a new cultivar of orchardgrass, named Sumas, and the confirmation that it is economical to restrict laying hens to 90% of their normal feed intake.

This report provides a brief insight into some phases of our research activities. Enquiries for further details about the data reported herein or on the Station program generally should be directed to the Research Station, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore
Director

ANIMAL SCIENCE

Beef production from F₁ Simmental × Holstein crossbreeds. The performance of 41 purebred Holstein-Friesian steers was compared with a group of 33 first-generation Simmental × Holstein crossbred steers. From a weight of 300 to 500 kg the Holsteins gained 1.35 kg/day, whereas the gain for the crossbreeds was 1.41 kg. Both groups had similar feed efficiencies during the finishing period, averaging 7.7 and 7.3 kg of feed/kg of gain for the purebreeds and crossbreeds respectively.

All steers were slaughtered when they reached 500 kg. The purebreeds had heavier carcasses (1.8%), lighter hides (20.1%), and more kidney, cod, and channel fat (17.0%) than the crossbreeds. The Holsteins dressed out at 55.3% compared with 57.5% for the crossbreeds. The purebred Holstein-Friesians had 8.9% less rib-eye area and 6.0% less rib fat than the Simmental crossbreeds. The depth of rib fat of both groups would have qualified most of the steers for the A1 or A2 grades according to the Canadian grade standards. Only one each of the crossbreeds and Holsteins exceeded the maximum 1.52 cm allowed for the A2 grade.

Mold inhibitors preserve high-moisture hay. Addition of 0.05% mold inhibitor to hay baled at 17 or 30% moisture or 0.2% mold inhibitor to hay baled at 40% moisture was effective in reducing losses due to spoilage when compared with hay baled at those moisture contents without the addition of mold inhibitor. However, hay baled at 40% moisture with 0.2% mold inhibitor added was

not accepted as readily as hay baled at 30 or 17% moisture with 0.05% mold inhibitor added.

Formic acid with direct-cut silage. The acceptance by lactating cows of high-moisture silage preserved with formic acid was equal to that of wilted silage, and the milk yield from cows fed silage treated with formic acid was equal to that from cows fed either wilted silage or corn silage. The efficiency of protein and energy conversion was greater for the silage treated with formic acid.

Effects of limited watering time on the performance of caged pullets and yearling hens. The limited watering time (LWT) treatment, which permits laying hens access to water for five equally spaced periods of 25 min/day, was compared with free access to water. When LWT was started with pullets at 21 wk of age, peak egg production tended to be lower, but there was no significant effect on annual mortality, egg production, or feed conversion. However, LWT for hens significantly improved both egg production and feed conversion. Egg quality traits including egg weight and percent solids in the albumens and yolks for both pullets and hens were not affected by LWT.

The timing of oiling, washing, and sanitizing of eggs to minimize deterioration of egg albumen. Eggs from each of two populations were sampled every 56 days for 14 mo. Strain differences in albumen quality were found. The decline in the quality of albumen during storage was reduced when eggs were

sprayed with a white, odorless paraffin-based mineral oil. Washing and sanitizing eggs had no measurable effect on albumen quality. By oiling the eggs on the day of lay and washing, sanitizing, and re-oiling them 3 days later deterioration of albumen quality was minimized. If eggs were stored only 7 days, washing, sanitizing, and oiling them on the day of lay gave similar results. Cloudy albumens in freshly oiled eggs were of no practical significance.

Restriction of feed intake in laying hens. Limiting the feed intake of laying hens to 80% of the intake of full-fed control birds reduced egg numbers in all periods of the laying phase. A 90% restriction slightly reduced egg numbers in the first third of the laying year, resulted in a larger reduction (5%) in the middle third, and showed no reduction the last third of the production year. Response to restriction of feed was influenced by the strain of bird, but not by the protein level of the rearing diet. Restricted feed intake reduced egg size and body weight proportionally to the level of restriction. The lower rate of lay is more than compensated by the feed savings at 90% restriction, but labor cost and egg-grade price differential also must be considered.

Effect of dietary protein on egg size. Egg size in young laying hens was influenced directly but not proportionally to dietary protein level. When the protein level in the laying ration was between 13 and 14% differences in egg weight were small compared with differences when the protein level was between 14 and 15%. Changes in percentage of medium-grade eggs suggest that a 15%-protein laying ration is the minimal level for maintenance of a high percentage of eggs in the grade "large" category.

CROP SCIENCE

Orchardgrass breeding. Sumas, a new cultivar of orchardgrass licensed in 1974, is a tall midseason cultivar similar to Hercules in maturity. It is resistant to lodging and has good winterhardiness for coastal British Columbia. Sumas is a four-clone synthetic whose basic clones were selected as follows: one from Pennlate, two from a Pennlate \times Gullaker cross, and two from an Ottawa 1947-3-11 \times Gullaker cross. Ottawa 1947-3-11 was an introduction obtained from the

Botanic Gardens, Basel, Switzerland. In hay and pasture trials, dry matter yields of Sumas have been equal to Sterling and Danish commercial, both earlier heading cultivars. There was no evidence of any inbreeding depression of vigor between the synthetic 1 and 2 generations. Neutral detergent fiber values for Sumas were relatively low, thereby indicating a higher than average expected digestibility for this cultivar.

Cultivar differences in tolerance of potatoes for metribuzin. Metribuzin has shown promise for weed control in potatoes but tolerance for the herbicide has varied. The results of a 3-yr study suggest that maturity (whether an early or late cultivar) and skin color are not necessarily correlated with tolerance or lack of tolerance for the herbicide. Norgold Russet, Epicure, and Kennebec were least affected (most tolerant) by the herbicide, whereas Early Rose, Warba, and Nettet Gem were the least tolerant. White Rose, Norland, Red La Soda, and Red Pontiac were intermediate. The weather before, during, and after application of the herbicide appeared to have an effect on the amount of plant injury. Injury to the more sensitive varieties was greatest when cloudy days preceded spraying and sunny days followed. Also, injury tended to increase when post-emergence sprays were applied during periods of high temperature.

High-density planting of broccoli. Trials were conducted over a 2-yr period to determine the optimum plant spacing and population density for mechanically harvested broccoli. Three broccoli cultivars, Gem, Duchess, and Pacifica, were direct seeded with a Stanhay precision seeder and thinned to 12.7, 19.0, and 25.4 cm in rows 22.8 and 30.5 cm apart. These spacings were compared with a standard planting of 45.7 cm in 61-cm rows.

The average marketable yield for all spacings showed that Duchess outyielded Gem and Pacifica, and Gem outyielded Pacifica. The 25.4 \times 30.5 cm spacing outyielded all other treatments when averaged for all cultivars. For the highest producing cultivar, Duchess, all close spacings except for that at 12.7 \times 22.8 cm outyielded the standard spacing.

Weights of spears affected by boron deficiency were recorded. Expressed as a percentage of marketable yield, Gem had 10.9% affected heads, Duchess 4.9%, and Pacifica

4.7%. Symptoms of boron deficiency increased as population density increased.

Moisture availability in nonsoil media. Because of the shortage in supply of vermiculite needed for peat-vermiculite mixtures, Douglas-fir sawdust and ground bark were used as substitutes. A 2:1 peat-sawdust or peat-bark mixture showed moisture-release characteristics for the easily available moisture that were quite similar to those of a 2:1 peat-vermiculite mixture. At suctions up to 60 g/cm², 500 ml of water could be extracted per litre of medium.

An increase in suction above 60 g/cm² extracted a further 50 ml per litre from the peat-vermiculite mixture but none from the peat-sawdust or peat-bark mixtures. This sharp decline in water availability in the mixtures containing bark or sawdust indicates that plants would wilt more suddenly in these mixtures than in the peat-vermiculite mixture, and would be more seriously injured. Precise measurements of moisture availability at increasing suctions will be used to formulate various nonsoil media for the specific requirements of the containerized nursery stock and bedding-plant trade.

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Research

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Research Station Kamloops, British Columbia

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¹Transferred from Research Station, Summerland, B.C., January 1974.

²Appointed August 1974.

INTRODUCTION

The research program of the Station at Kamloops was strengthened in 1974 by the appointment of two new staff members. Dr. W. Majak, a plant biochemist, will be isolating miserotoxin, the poisonous principle of timber milkvetch, and investigating the metabolism of the toxin in cattle. He will also study other native toxic plants that account for substantial cattle losses on range each year. Mr. F. M. Chapman, a forage crops specialist, will be responsible for management studies with alfalfa and grasses throughout south-central British Columbia, as well as at the Substation at Creston in the southeast of the Province.

A project on reseeding of grassland range was started. The aim is to obtain a satisfactory forage stand on ranges that vary from sparse sod with a heavy overstory of sagebrush to dense grass sod without an overstory. The suitability of five types of tillage implements will be assessed under these varying range cover conditions.

Further progress was made in establishing a suitable low-cost system for monitoring soil moisture on dryland ranges by means of a thermocouple-physchrometer.

Only highlights of our 1974 research are presented in this report. Further information concerning details of work discussed can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, P.O. Box 940, Kamloops, B.C. V2C 5N5.

D. E. Waldern
Director

PLANT BIOCHEMISTRY

Poisonous Principles in Timber Milkvetch and Related Legumes

The variability in concentration of miserotoxin was studied in 120 individual plants of timber milkvetch, *Astragalus miser* Douglas ex Hooker var. *serotinus* (Gray) Barneby. The plants were harvested at the bud, flower, and pod stages from rangeland locations in the rough fescue grassland, parkland, and Douglas-fir zones. The concentration of miserotoxin was determined as a percentage of dry weight of the aerial shoots. Although a wide range in miserotoxin levels was evident within each sampling unit of 10 plants, the grassland samples showed the greatest toxicity, with an exceptional level ($10.2 \pm 1.1\%$) during the bud stage. The parkland samples at the bud stage yielded an intermediate concentration ($5.2 \pm 1.2\%$), and forest plants contained lower miserotoxin levels (4.1 ± 0.9 to $2.5 \pm 0.5\%$). Miserotoxin levels declined during the bud-to-pod growth interval in plants harvested from the grassland and parkland sites, but significant differences were not apparent between the progressive stages of growth at the forest locations. The toxicity patterns of timber milkvetch based on the variability of individual plants confirmed previously described trends derived from composite samples collected over the growing season.

Glucose esters of 3-nitropropionic acid (the toxic constituent of *Indigofera endecaphylla* Jacq.) have been detected in *Astragalus collinus* (Hook.) Douglas, *A. canadensis* L., *A. robinsii* (Oakes) Gray, and *Coronilla varia* L. (crownvetch); the former three are native rangeland legumes whereas the latter is an introduced species.

WEED CONTROL

Reseeding combined with Chemical Control of Knapweed

Knapweeds (*Centaurea* spp.) have spread rapidly on the rangeland of the British Columbia interior during the past 20 yr. All species, diffuse, spotted, and Russian knapweed, are adapted to a wide range of soil and climatic environments and are easily spread by vehicles and livestock. At present, more than 202 000 ha (0.5 million ac) have been invaded, greatly reducing the growth and forage yields of the native grasses. This in turn has lowered the annual carrying capacity of the ranges.

When picloram was applied at 0.28 kg active ingredient (ai)/ha before seeding, most of the knapweed was killed. After seeding with the rangeland drill, an excellent stand of crested wheatgrass was established, as indicated by the progressive increase in dry matter yield of native vegetation plus

crested wheatgrass over the next 4 yr. Crested wheatgrass and native vegetation in plots treated with picloram at 0.56 kg ai/ha exhibited toxic effects. After 4 yr, forage yields from plots treated at the heavy rate were equal to those of untreated plots seeded with crested wheatgrass.

The herbicide picloram controlled knapweed well and, on plots reseeded with crested wheatgrass, forage yields increased by 135 kg/ha over those of the untreated native range. Good management practices must be observed if dryland ranges of the interior region of British Columbia are to be improved.

FORAGE PRODUCTION AND UTILIZATION

Long-term Response of Range Vegetation to Fertilizers

Fertilizers were applied in the fall for 4 yr, 1959–62, to new sets of plots at each of five sites on native grassland range. The sites were located at elevations from 520 m on Brown Chernozemic soils, through intermediate on Dark Brown soils, to 945 m on Black soils. Eight treatments, indicated as kg of element/ha, were used: 0 N (control); 18 N; 55 N; 168 N; 503 N; 1412 N; 503 N + 219 P; and 503 N + 219 P + 419 K + 985 gypsum + 45 fritted trace elements.

Results were highly variable from year to year, but culm production and overall forage dry matter yields increased as the level of N applied was increased to 168 kg/ha. Nitrogen applied at 503 and 1412 kg/ha severely injured a high percentage of native forage in the 1st yr, and later years on the Brown and Dark Brown soils. Sandbergs bluegrass was completely destroyed by N at 1412 kg/ha. There was evidence of an added effect of P with N, and of the complete fertilizer, probably the S component, on the Black soil site. Forage stands responded progressively to higher levels of applied N at sites located on the Brown, Dark Brown, and Black soils. Higher forage yields were associated with greater moisture availability at the higher elevations. Dry forage yields from individual control plots in the entire series ranged from 126 to 1344 kg/ha and those from treated plots, from 133 to 4725 kg/ha. In 1960, sheep gained access to one of the plot areas

and showed a preference for the vegetation on fertilized plots.

Native vegetation on certain grassland plots still showed yield responses until 1966 from fertilizers applied in 1959. Recovery from toxic effects of very high rates of fertilizer (503 and 1412 kg N/ha) appeared to be complete by 1966 on the Black soil of the upper grasslands. To date, however, weeds still exceed the preferred forage species on many heavily fertilized plots on the Dark Brown and Brown soils of the middle and lower grasslands. Recovery at the higher elevation is believed to be the result of greater moisture effectiveness.

Compatibility of Grass Seeding and Conifer Regeneration on Clear-cuttings

The competitive effect of grass seeding on regeneration of coniferous trees in clear-cuttings in the south-central interior of British Columbia was studied in cooperation with the Research and Grazing divisions of the British Columbia Forest Service.

Experimental sites were sown with nonrhizomatous species of domestic grasses, and subsequently grazed. The objective was to examine the effects of these practices on the establishment, survival, and growth of coniferous tree species (mainly lodgepole pine), and upon the re-establishment of native shrubs and forbs.

Where numbers of cattle and the period of grazing were adequately controlled, the damage to conifer seedlings was negligible. Where numbers of cattle were regulated but the grazing period was prolonged so that forage was over-utilized, damage to conifer seedlings was extensive. Where the number of cattle was uncontrolled and the experimental sites were part of a much larger grazing unit, the forage was over-utilized and damage to conifer seedlings was at an unacceptable level.

The cases where cattle caused extensive damage usually resulted from inadequate management, such as poor distribution of salt or failure to move cattle at the proper time. Generally, the presence of domestic grass had no effect on germination or survival of conifers. Where growth was inhibited, the competition from native vegetation was of as much consequence as the competition from domestic grasses.

Feeding Habits of Cattle and Mule Deer on Ranges

A cooperative study was started in 1971 with the British Columbia Fish and Wildlife Branch and Forest Service, to investigate potential competition between deer and cattle for the range resource. Two areas are under study, a winter and a summer range of deer, with emphasis on the former.

Competition for the same plants was minimal on the winter range when cattle grazing was kept at recommended levels. On this range, cows fed almost exclusively on grass whereas deer used mainly Douglas-fir, with approximately equal proportions of rabbitbrush, pasture sage, and big sagebrush. The potential for competition is greatest in late winter and early spring, when deer depend largely on nutrients from new grass or grass produced the previous fall to replace lost body weight and supply nourishment to unborn fawns. In this period, grazing practices of the previous year and current spring can either adversely or positively affect the deer's diet, and consequently their nutritional status. Fall grazing by cattle removes the mature stalks of bluebunch wheatgrass and gives the deer easier access to the new grass in the spring, encouraging them to feed on high-quality forage. On the other hand, if cows are introduced on the range before enough grass has grown to support them

adequately, they will compete directly with the deer for that grass. Fortunately, deer are versatile feeders and will switch to the less nutritious shrubs or to herbaceous plants if they are available.

During the summer, cattle have readily taken shrub species such as willow and rose, which are important to deer when they graze the same areas in the fall. In areas of limited availability of grass or in periods of drought where shrubs are disproportionately more palatable than grass, cattle consume more of the shrubs. The effect on deer would be related to their dependency on that range.

Persistence of Alfalfa Yields

The failure of alfalfa to maintain high yields from year to year is most evident in the interior region where stands are grown under irrigation and a three-cut regime. In 235 alfalfa cultivar test years, the highest yields of dry matter were obtained from the first crop year. The decline in yield between the first and third crop years was 11% and between the first and fifth crop years, 28%. This decline was most rapid and erratic in the last 2 yr of the 5-yr test periods. The decline in yield ranged from 4 to 31%, with a mean of 17%. The yield reductions of the standard cultivars, Beaver and Vernal, were similar to the mean of all test cultivars in the early crop years. In the later crop years, the yield decline was half the mean of all test cultivars, 8%.

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Research Station Sidney, British Columbia

PROFESSIONAL STAFF

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R. G. ATKINSON, B.S.A., Ph.D.	Diseases of glasshouse crops
N. V. TONKS, B.S.A., M.S.	Insects of ornamentals
D. R. BERTOIA, B.S.A.	Officer-in-charge, Post-entry
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INTRODUCTION

The Research Station at Sidney, B.C., emphasizes research on problems of ornamental and greenhouse crops. Particular attention is being paid to the culture of greenhouse vegetables and ornamental nursery stock by the use of soilless media in containers. Priority is also given to the propagation of superior clones of the Douglas-fir in cooperation with the forest industry. The work is rapidly expanding at the Post-entry Quarantine Station, which is operated jointly with the Plant Protection Division, Agriculture Canada.

Requests for information or publications should be addressed to the Research Station, Research Branch, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

H. Andison
Director

HORTICULTURAL CROPS

Greenhouse Tomatoes

Soilless production of tomato plants. Some of the advantages of growing tomato plants to the transplanting stage in soilless mixes instead of in soil include consistency of plant uniformity and quality, lightness of weight of the soilless media, and, usually, decreased costs. Where the crop is produced in sawdust, a further benefit is that, in contrast to soil-grown plants, no microflora are added at transplanting to decompose the sawdust and reduce availability of N. A 2:1 mixture of sphagnum peat - vermiculite with hydrated lime added at 2 kg/m³ to offset the effect of acid peats has been highly satisfactory. A complete nutrient solution, with N at 126 ppm, is applied when moisture is required. Where vermiculite is unobtainable, sawdust has been substituted with good results.

In trials with dry premixed fertilizers, plants of excellent quality were produced from a formula consisting of MagAmp (W. R. Grace and Co.) at 6 kg/m³, Osmocote 14-14-14 and Osmocote 18-6-12 (Sierra Chemical Co.) at 1.5 and 3 kg/m³, respectively, hydrated lime at 2 kg/m³, and minor element solution. Benefits include an assured nutrient supply and elimination of the need for preparing and accurate dispensing of liquid feeds to ensure adequate nutrition during the growing period of the plant.

Greenhouse Cucumbers

Fertilizer formulas in soilless production. In studies of the production of seedless cucumbers in a sawdust growing medium, modifications to the fertilizer formulas used for tomatoes were found necessary. Steady growth and good development of fruit were

obtained when the level of N in the nutrient solution was maintained at 168 ppm. When N was supplied at 210 ppm, which is the rate supplied to tomatoes after fruit is set on the third flower cluster, the cucumber leaves were excessively large and dark green and the growth of new shoots slowed down. The amount of Ca in the tomato formula must be increased by approximately 50% to satisfy the greater absorption of this element by cucumbers. In other proportions, the formula used for tomatoes was adhered to for cucumbers with good results.

Ornamentals

Soilless media for plant production in containers. Growth of plants of *Erica* × *darleyensis* *alba*, *Juniperus chinensis* 'Pfitzeriana Compacta', and *Thuja occidentalis* 'Pyramidalis', from cuttings rooted the previous season, was compared in 3.8-litre polyethylene containers of sawdust, shredded Douglas-fir bark, 1:1 sawdust - fir bark, and 3:1 sawdust - sphagnum peat mixtures, and soil. The soilless media that were tested with and without a 1.3-cm topping layer of sand had part of the nutrient requirements supplied by premixed fertilizers and part by a 20-20-20 solution through trickle tubes. Osmocote 18-6-12 (W. R. Grace and Co.) was premixed with the soil (a 3:1 sandy loam - peat mix) at 3.6 kg/m³.

Growth was more uniform throughout the season in the soil than in the soilless media, although growth rates in the latter tended to be greater during the early and mid parts of the season. Of the soilless media, growth was greater in fir bark than in sawdust. Satisfactory growth occurred in the sawdust - fir bark and sawdust-peat treatments, but, except for *Thuja*, where better moisture

retention in the latter mixture favored late growth, no advantages over fir bark were observed. By conserving moisture, the surface layer of sand on sawdust-containing media tended to increase growth during the mid and late season, particularly of juniper in sawdust, but the layer of sand had little beneficial effect on fir bark.

Because of quick growth in soilless media, plants of *Thuja* became pot bound by late August, and basal leaves began to turn brown. In such media, plants of this species do better in larger containers.

Weed Control

Selective control of velvet grass in turf. An experiment was conducted to compare chemical treatments for the selective removal of velvet grass, a persistent perennial weed of turf grass, common in the Pacific coastal region. An infestation was produced artificially by sowing seed in flats of soil in December in the greenhouse, pricking out the seedlings individually into soil-filled asphalt paper rings, and in early April setting these into regularly spaced holes in an established bluegrass-fescue turf. The velvet grass was growing vigorously when the spray treatments were applied in June.

After promising results in the previous year, almost complete eradication of velvet grass was obtained from a single application of lenacil at 5.6 kg/ha (5 lb/ac). A treatment at 11.2 kg/ha (10 lb/ac) followed by two applications of 5.6 kg/ha 2 wk apart caused some loss of vigor and thinning of the turf grass. In an attempt to stop further herbicide activity and to reduce turf damage, an activated charcoal slurry was applied 1 wk after a treatment at 11.2 kg/ha, but it had little effect. None of 16 other herbicide treatments were effective in eliminating the velvet grass.

Woody Plants

Propagation of woody plants. MacMillan Bloedel Ltd. and Pacific (CPR) Logging Co. continued to cooperate in the propagation experiment supplying 20,000 Douglas-fir cuttings from "plus" or superior selected trees. The best results were obtained when cuttings were taken during January, dipped in an indolebutyric acid (IBA) 50% alcohol solution at 1000 ppm, and rooted in a 1:1:1 sand-peat-perlite medium. IBA powder (Seradix 3; May & Baker Ltd., Dagenham,

England) at 8000 ppm was not as effective. Of 173 clones used, 32 failed to produce roots.

When cuttings were taken in mid-August from four common evergreen shrubs (*Chamaecyparis lawsoniana* 'Alumii', *Juniperus communis* 'Compressa', *Picea pungens* 'Globosa', and *Pinus mugo* var. *pumilio*) and treated with the same two hormones and rooting medium as in the previous test, the IBA solution was twice as effective as the IBA powder. The addition of either benomyl or Banrot (Mallinckrodt) soil fungicides to the hormone powder did not improve the rooting percentage.

Vegetative propagation of virus-tested varieties of tree fruits was continued with the use of root or softwood cuttings of dwarf apple stock of MM 104, MM 106; M 7, M 9, and M 26. Best results were obtained on all of this material from root cuttings taken during mid-March. Results varied with the diameter of the roots. Rooting was best when pieces of root 50–75 mm long and 6–7 mm in diam were placed on sand and covered with peat moss.

Softwood cuttings of all rootstocks, except virus-free No. 9, resulted in 25–50% rooting when taken during July and August and treated with IBA powder at 8000 ppm.

Post-entry Quarantine Station progress report. In 1974, the Post-entry Quarantine Station, located at the Research Station, Sidney, received 108 clones of *Vitis* and 234 clones of tree fruits. Virus infection was found in 62 clones of *Vitis* and 56 clones of tree fruits. About 280 virus-tested clones have been indexed and found free from known viruses. These clones are grown in isolation in the repositories at the Station and are available to research and industry.

The heat-therapy program has reached full development, but the effectiveness of the heat treatment will not be known until the clones have been reindexed.

Salix spp. are being observed and tested in quarantine for the presence of watermark disease, caused by *Erwinia salicis* Day. When the plants have been proved free from the watermark disease, they will be released to the consignees to act as a repository for a source of willows.

Black root rot of greenhouse cucumbers. In growth-room studies on black root rot, caused by *Phomopsis sclerotioides* Kest, of long English cucumber cv. Greenspot, F₁

hybrid, a single soil drench of benomyl or thiophanate-methyl at 100 ppm or 200 ppm (ai wt/vol soil), applied the day after 18- or 19-day-old seedlings were transplanted into infested soil (10% vol/vol inoculum), gave excellent control of the disease. In two experiments, only one of the 32 plants drenched with either systemic fungicide at these rates became infected. Similar drenches at 50 ppm were less effective, but benomyl was twice as effective (two diseased plants in eight) as thiophanate-methyl (five in eight). All 16 plants in untreated infested soil became infected.

Control of the Black Vine Weevil

On grape. Grape cv. Baco 22-A planted in tubs infested in May with eggs of the black vine weevil was treated once in July with oxamyl at 0.5, 1.0, and 2.0 g of toxicant/litre of water applied either as a foliage spray or as a soil drench at 30 ml/1000 cm³ of soil. The soil in the tubs was examined for weevil larvae in October. The mean number of larvae recovered per pot for the control was 19.0; oxamyl spray at 0.5 g of toxicant, 13.4; oxamyl spray at 1.0 g, 14.2; oxamyl spray at

2.0 g, 7.8. The highest dosage rate of spray significantly reduced weevil infestation in comparison with the lower dosage rates and controls. Soil drenches completely eliminated the weevil larvae but phytotoxicity was severe at all rates for this method of application.

On fuchsia. Fuchsia cv. Swingtime in tubs infested in June with eggs of the black vine weevil was treated once in June with oxamyl at 2.4 g, carbofuran at 0.6 g, diazinon at 0.6 g, and malathion at 1.2 g of toxicant/litre of water applied as soil drenches at 30 ml/1000 cm³ of soil, and oxamyl at 2.4 g of toxicant/litre as a foliage spray. The weight of mean roots in November for the control was 2.90 g; oxamyl spray, 5.33 g; diazinon drench, 5.62 g; oxamyl drench, 5.94 g; malathion drench, 6.37 g; carbofuran drench, 8.88 g. Very few larvae were recovered after any of the treatments. Untreated plants had almost no roots. The roots of all treated plants were significantly heavier than those of the controls. The weights of roots from plants treated with carbofuran drench were significantly heavier than those of plants given all other treatments.

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Research Station Summerland, British Columbia

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J. C. LAVERY, B.Sc., B.L.S.	Librarian

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P. PARCHOMCHUK, B.A.Sc., M.S.	Harvesting equipment

Animal Science Section

J. M. McARTHUR, B.A., M.A., Ph.D.	Head of Section; Bloat research in cattle
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F. L. BANHAM, B.A.	Stone-fruit insects
R. S. DOWNING, B.A., M.S.	Control of mites
A. P. GAUNCE, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
R. D. McMULLEN, B.Sc., M.Sc., Ph.D.	Bionomics of pear psylla
J. D. MACNEIL, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

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J. A. KITSON, B.A., M.S.	Head of Section; Process and product development
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Head of Section; Fruit harvesting
 and storage
 Rootstocks—grapes, peaches
 Fruit breeding and hardiness
 Agrometeorology, growth regulants
 Postharvest physiology,
 biochemistry

Departures

F. M. CHAPMAN, B.S.A.
 Transferred January 1974 to staff of Research
 Station, Kamloops, B.C., but located at
 Summerland
 K. O. LAPINS, Agr., M.S.A., Ph.D.
 Retired June 1974
 C. V. G. MORGAN, B.S.A., M.Sc.
 Retired September 1974

Cereals, forage crops
 Fruit breeding and hardiness
 Control of grape insects and mites

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 J. A. FOOTT, B.S., M.S.

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 Pomology

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Entomology, plant pathology

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J. M. LEE, B.Sc., M.S., Ph.D.
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Pomology
Food processing

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²On work transfer to Research Station, Agriculture Canada, St-Jean, Qué., Aug. 1974 to June 1975.
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INTRODUCTION

This report provides a sample of research activities in the various sections at the Station. The value of having a body of research knowledge available to meet an emergency was recently shown when the outbreak of "little cherry" virus occurred in 1973 and 1974. Thanks to the expertise in plant pathology at Summerland, the new knowledge gained from work transfers by Drs. Welsh and Hansen and from Dr. M. W. Neilson, on transfer from the U.S. Department of Agriculture in July and August, and fine cooperation with the Research Station at Vancouver, the Little Cherry Committee of the British Columbia Fruit Growers Association, and officers of the B.C. Department of Agriculture, the outbreak at the moment appears to have been contained. New knowledge on identification and early detection of the virus is developing rapidly in the research stations at Summerland and Vancouver.

During the year the Station has served the fruit industry well with a record number of scientific and popular publications, as well as participation at many grower meetings and presentations on TV and radio.

We wish to record with appreciation the long and valued professional service rendered by Mr. C. V. G. Morgan and Dr. K. O. Lapins who have retired, and of Mr. Frank Chapman who transferred to the Research Station at Kamloops.

The Station has benefited during the year from the following scientists here on work transfers: Dr. M. W. Neilson, USDA; Dr. D. G. Blanpied, Cornell University; Mr. R. L. Granger, Research Station, St-Jean, Qué.; and Mr. J. A. Foott, University of California. We also wish to welcome NRC postdoctorate fellows Dr. J. Lee and Dr. E. Warrendorf.

For further information on the scientific and industry-related programs of the Station, correspondence should be addressed to Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

D. V. Fisher
Director

AGRICULTURAL ENGINEERING

Comparison of Two Sprayers for Mite Control

Experiments were conducted with sprayers for control of the European red mite infesting semidwarf Red Delicious apple trees. An inexpensive hydraulic upright-boom sprayer that applies spray mixture at 1600 litres/ha was compared with a Turbo-mist airblast sprayer that applies 650 litres/ha. When trees at the 13-mm (1/2-in.) green bud stage were sprayed with dormant oil, the airblast sprayer gave better control of mites than the hydraulic sprayer. The mites were then in the immobile egg stage and thorough spray coverage was needed for control. At the pink bud stage, when cyhexatin was used as the acaricide, there was little difference between levels of control achieved with the two sprayers. By that time most of the eggs had hatched and the residual toxic effect of cyhexatin against the mobile immature mites masked any effect of incomplete coverage by the hydraulic sprayer.

Tower Sprayer for Semidwarf Orchards

The experimental tower sprayer again gave better seasonal control of the codling moth in a badly infested orchard of semidwarf apple trees than did a good conventional airblast sprayer. The tower sprayer distributed the spray chemical more uniformly from bottom to top of the trees, and less spray material drifted to the atmosphere.

Experimental Vineyard Sprayer

The experimental grape sprayer built in 1973 was modified to direct more of the spray to the underside of the leaves. Its performance was compared with that of a good orchard airblast sprayer and a vertical-boom hydraulic sprayer. The experimental sprayer gave greater spray deposits on the grape leaves, and better control of leafhoppers, than either of the other sprayers; the other airblast sprayer ranked second.

Mechanical Aids for Hand Harvesting of Tree Fruits

The self-propelled work platform was used for several days of harvesting in a commercial planting of Bartlett and Anjou pears in which tree rows were 4.3 m apart and the trees were about 4 m high. Although the picking rate was only slightly faster than the rate of conventional harvesting with ladders and bags, the crew preferred working on the platform because they felt less tired at the end of the day.

Blockage of Trickle Irrigation Emitters

Blockage of trickle irrigation emitters was found to be caused by agglomeration of silt and clay particles. Fine filtration or the use of a settling basin did not remove the particles. When the lines feeding the emitters were flushed continuously or at intervals up to once every 4 wk, plugging was not reduced. However, when the emitters were operated for one-third of the time but at three times the normal continuous-flow rate, the plugging was eliminated or greatly reduced. Sodium hypochlorite injected into the water at rates of 10 and 100 ppm chlorine for 15 min each week not only prevented plugging but actually cleared emitters that had been plugged before the injections.

ENTOMOLOGY

Codling Moth

Control by sex attractant traps. It has been theorized that, after a population of codling moths has been reduced to an extremely low level by release of sterile insects or by pesticides, it might be possible to maintain control solely by removing males with sex attractant traps. However, two experiments, one with 10 traps/ha and the other with 34, suggest that this procedure is not sufficiently effective to prevent a gradual increase in density of codling moths. In both experiments, the number of moths captured and the percentage of damaged fruit were significantly higher in 1974 than in 1973.

Monitoring with sex attractant traps. Sex attractant traps have been used for three consecutive seasons to determine the need for and the timing of measures to control the codling moth. Data have shown that a density of 1 trap/ha is sufficient to sample an

orchard, that traps must be placed in neighboring orchards to minimize migration of moths into monitored orchards, and that a capture of two or more moths/ha per week indicates potentially damaging activity level. In six experimental orchards, the average number of sprays required to control codling moths during the 3-yr period was 2.2 in 1972, 1.8 in 1973, and 1.6 in 1974.

Orchard Mites

Biological control. Seven apple orchards, which have been under a continuous program of integrated control of mites for eight seasons, were examined in 1974. There was a good balance in all the orchards among the apple rust mite, the European red mite, and two predaceous species, *Typhlodromus occidentalis* Nesbitt and *Zetzellia mali* (Ewing). It has not been necessary to use summer sprays against mites in any of the orchards, and in two of the seven dormant oil has not been applied as an aid to control of European red mites for 2 yr. These orchards are a good example of the effectiveness of biological agents in the control of phytophagous mites.

Chemical control. A number of candidate acaricides were evaluated as pink bud and summer sprays to control the European red mite. Bay Bue 1452 (Chemagro Corporation), benzoximate, R-28627 (Stauffer Chemical), SD-14114 (Shell Canada), and cyhexatin gave good control, and as pink bud sprays they were not toxic to the predator *T. occidentalis*. Summer sprays of PP-213 (Chipman Chemical), benzoximate, and cyhexatin effectively controlled the European red mite, but benzoximate allowed a greater survival of *T. occidentalis*, thus providing a better balance of prey and predator.

Pear Pests

Chemical control of pear psylla. Dormant oil plus either endosulfan or ethion gave excellent control of overwintered adults of the pear psylla. In early June, endosulfan plus ethion gave better control of adults and nymphs than endosulfan alone or azinphos-methyl plus ethion. Seven insect growth regulators were evaluated for control of the pear psylla in early September. Five of the compounds reduced numbers of adults more than 92%, and the other two gave reductions of 84 and 85%. The reduction of nymphal

stages was considerably less, varying from 6 to 49%.

Cherry Fruit Flies

Traps and attractants. Catches of black and western cherry fruit flies were increased 10.1% when vertical saturn yellow wings were fitted on Pherocon ICPY traps baited with Mago caps (Zoecon Corporation). Zoecon apple maggot traps with attractant incorporated into the sticky material caught 52.4% more flies than unbaited traps with yellow sticky boards. Unbaited saturn yellow Prokobil traps (E. F. Boller, Wadenswil, Switzerland) caught 35.2% more black and western cherry fruit flies than unbaited yellow sticky boards and 47.1% more than Pherocon ICPY traps baited with Mago caps.

Fruit fly distribution. A total of 2,304 western cherry fruit flies treated with ^{32}P were released in a block of sweet cherries. The accumulative percentage of radioactive flies recovered at various times and distances from the release site was: 1% at 1 h, to 24 m; 3.3% at 4 h, to 110.7 m; 11% at 7 days, to 122.9 m; 12.9% at 14 days, to 255.8 m; and 32% at 28 days, to 268.1 m. The total recovery was 33.2% after 42 days. The recovery was highest during days 14 to 21 and the ratio of marked flies to wild flies was 1:5.75.

Fumigation

All larvae of the codling moth in 100,000 infested apples were killed by fumigation with methyl bromide at 32 g/m^3 for 2 h at 17°C followed by 31–35 days of storage at -0.5°C . Standard cold storage (at -0.5°C) killed all first- and second- and some third-instar larvae in nonfumigated fruit. Cursorry sampling indicated that fumigation alone, without subsequent cold storage, could kill all stages. The fumigation and storage treatment did not injure Red Delicious, Golden Delicious, Spartan, Jonathan, or Newtown apples.

FOOD PROCESSING

Low-effluent Steam Blanching

The blanching process is a major contributor of organic wastes in vegetable canning and freezing plants. An attempt was made to eliminate this pollution source by using a

rising film evaporator heated by direct gas flame as a generator to supply steam to a blancher. Feed water for this steam generator consisted of waste water from the blancher, thus eliminating the latter as a source of biochemical oxygen demand in the plant effluent. Soluble material in the blancher waste was concentrated in the generator and bled off as a concentrate at 40–50% solids, which might be used as an animal feed additive or as a raw material for fermentation.

The system shows promise but the problem of "burn-on" in the tubes of the heat exchanger requires solution. Burn-on reduces the heat exchanger's efficiency and causes off-odors in the steam produced.

Use of Vegetable Waste

A juice was extracted from harvest debris of celery; it contained celery flavors in addition to nutrients, vitamins, and crude protein. Undesirable green color and much of the bitter flavor in the juice were eliminated when a residual chloroplast fraction was removed by centrifugation. The nearly colorless liquid obtained by this process was found suitable for the preparation of blended vegetable juices, which were rated equal to or better than comparable commercial samples.

Concentration and Encapsulation of Aroma

The process for encapsulation of concentrated fruit aromas was improved to eliminate the caking of the granular or powdered product during high-temperature storage. This was accomplished by drying the processed product with low-humidity air in a through-flow bin drier. As another improvement, the encapsulating agent was modified to permit coencapsulation of the oil- and water-soluble components of aroma. A high-quality orange-flavored powder resulted from this modification.

Difficulties were encountered in obtaining concentrated essences other than apple from the $0.1 \times 3\text{-m}$ (4 in. \times 10 ft) vacuum column used for aroma concentration. However, 2000- to 4000-fold concentrates of raspberry, strawberry, pineapple, and water-soluble orange were prepared with a laboratory-scale rotary evaporator. All these essences were encapsulated, and after storage

for 5 mo there was no evidence of flavor breakdown of the polymer.

An intermediate-stage product in the preparation of dry encapsulated fruit aromas was found suitable as a flavoring for soft-centered candies. The patented product, a fondantlike paste, is prepared by heating a concentrated solution of sucrose, glucose, and maltodextrins to 140–145°C, a temperature at which polymerization occurs. The molten polymer is diluted to 85–88% solids with water, cooled to 20°C, and mixed with a concentrated fruit aroma combined with a starch-derived gum. The aroma becomes incorporated in the mixture so that it is not released until the candy filling is eaten and diluted by saliva.

Fresh-chilled Peaches

Controlled-atmosphere storage of fresh peaches before peeling, slicing, and storage as chilled peach slices appears to eliminate the almondlike off-flavor encountered with this product. The most promising treatment comprised storage of the fruits for 1 mo in a controlled atmosphere of 2–3% oxygen and 5% carbon dioxide before they were processed. This treatment prevented the development of the off-flavor. However, it adversely affected the overall peach flavor and the texture, so that further study is required to develop an acceptable product.

Dry Table Wines from British Columbia Compared with Imported Wines

Analytical and taste-panel comparisons were carried out on 15 dry table wines produced in British Columbia and 17 imported dry table wines. The imported wines, from Australia, California, Chile, France, Germany, and Hungary, were selected from within a price range that made them most likely competitors to B.C. wines. The taste panel, consisting of eight trained members, used a nine-point Hedonic scoring system, where 9 represented “like extremely” and 1 represented “dislike extremely.” Among red wines, eight B.C. wines had an average score of 5.9 and ten imported wines were rated 5.8; among the whites, seven B.C. wines scored 5.6 and seven imported wines scored 5.8. Some analytical differences were evident, the most interesting being in tannin and sugar levels. In general, B.C. red wines were lower in tannin than imported reds and B.C.

white wines were lower in sugar than imported whites. Although limited, the results indicate that, in the categories studied, wines produced in British Columbia are comparable to their imported counterparts and an excellent buy at present prices.

PLANT PATHOLOGY

Target Spot, False Twisted Leaf, Xylem Aberration, and Detrimental Canker of Sweet Cherry Caused by a Single Virus

Further investigations were carried out on cherry trees affected by target spot, false twisted leaf, xylem aberration, and detrimental canker. Symptoms comprised target spot and surface irregularities of fruit, twisting and spot necrosis of leaves, black canker with gum on twigs, and pitting and grooving of wood on the lower trunks, and two or more of them often occurred together on the same tree. Attempts to transmit a virus to herbaceous hosts from affected leaves, branches, and fruits from British Columbia and Czechoslovakia consistently yielded tomato bushy stunt virus. This indicates that the various symptoms are manifestations of the same disease. In immunoelectrophoresis, isolates from a Canadian and a Czechoslovakian cherry source and from a German grape source were identical.

A Filamentous Virus from Guar

Guar, *Cyamopsis tetragonoloba* (L.) Taub., a leguminous plant used for vegetable, fodder, and gum production in India and the United States, is a useful indicator of stone fruit viruses in Canada. Sap transmission studies have revealed the presence of a seed-transmitted virus in this legume. The virus was present in all 27 American and Indian seed samples tested. In preliminary identification studies, the host range was limited to a few legumes and three species of *Chenopodium*. Thermal inactivation point was 55°C and dilution end point between 1:10 and 1:100. Attempts to produce an antiserum were unsuccessful because of low virus concentration. Length of particles varied between 725 and 800 nm. The presence of pinwheels in guar and in indicator plants indicates that this virus belongs to the potato virus Y group.

Graft-transmissible diseases causing brown line of apples have received intensive study. Additional rootstock clones are proving to be sensitive, and larger numbers of clones of commercial apple cultivars are found to be infected. There is strong evidence that such abnormalities at stock-scion unions are associated with at least two distinct diseases. One is characterized by presence of a deep groove in the woody cylinder, encircling the union, and the other by a concentration of pits in the wood at the union. In both cases, the depressions in the wood are filled with brown, killed bark tissue. Affected trees always suffer reduced vigor, and frequently decline and die. In intensive tests of sap transmission to herbaceous plants, the first type of brown line consistently yields the apple stem grooving virus. Attempts to transmit the agent of the second type by sap have not been successful.

Chlorotic Leaf Spot Virus in Sweet Cherry

Chlorotic leaf spot virus was recovered from several sweet cherry trees affected by little cherry disease when sap was rubbed on leaves of *Chenopodium quinoa* Willd. It was obtained only from trees that showed some abnormality of the fruit. The occurrence of this virus in sweet cherry trees in North America may be more common than had been realized. It is not yet known if the occurrence of chlorotic leaf spot virus in sweet cherry is related in any way to the presence of little cherry disease.

Control of *Corticium* Rot of Apple

Control of *Corticium* rot of apple by a postharvest fungicide dip has generally been poor, with one notable exception: a mixture of captan and benomyl, which reduced *Corticium* rot 94%. Activity of the two materials applied together was far greater than the sum of each applied separately. Results of other tests indicate that benomyl has a similar synergistic effect when added to the fungicide captafol.

Retardation of Softening in Apples

After 6.5 mo, McIntosh apples treated with 10% carbon dioxide for 7 or 14 days before controlled-atmosphere storage were at least 0.5 kg firmer than fruit placed in controlled-atmosphere storage immediately after harvest. The results were similar for random samples of 42 commercial lots of fruit. Carbon dioxide at 20% delayed softening more, but caused excessive injury. At present, 10% carbon dioxide for 10–14 days seems a safe treatment, but more information is required to assess effects of seasonal and other factors on susceptibility to injury.

Storage Defects in Sweet Cherries

Cherries can be damaged during what are considered normal picking and packing procedures. A free drop of fruit, for a distance of only 30 cm, into a plastic or fiberboard container resulted in the development of surface lesions in cold storage. Machinery used to separate individual cherries from clusters during packing caused an 8- to 10-fold increase in defects, which became apparent after fruit was returned to cold storage. The cultivar Van sustained more damage than Lambert, and immature fruit more than mature fruit.

Reduced Breakdown in Apples from Hypobaric Storage

Breakdown of Spartan fruits was controlled by exposing them in cold storage to reduced atmospheric pressure (100 mm Hg) for 2 wk after harvest. This treatment resulted in 3.8% breakdown after 5-mo storage compared with 23.4% in the control samples. The low-pressure treatment reduced respiration rate, but did not affect ethylene production.

Ripening of Pears Promoted by Chilling

Exposure of Bartlett pears to ripening temperatures for 2 days immediately after harvest was compared with similar exposure of fruit that had been in cold storage for 10 days. After 8 wk of cold storage, pears that had been warmed after the chilling period were fully yellow and mostly ripe for eating, and some showed breakdown when removed from cold storage. Those exposed to ripening conditions before storage were hard and green and required a further 5 days to ripen.

Compact Growth Genotypes Identified

Two-year-old apple seedlings from 30 families, representing crosses between radiation-induced mutants of McIntosh, selections from compact-growth seedlings, or named cultivars, were examined. Families varied widely with respect to the percentage of compact seedlings produced. The German cultivar Alkmene transmitted very desirable growth to about 25% of the progeny. Other promising parents were Golden Delicious seedling selections 5G-9-17, 8B-65-38, and 8B-65-53. Certain seedling selections from Germany, Klon 237, S.LX 15/6, and S.LX 13/37, in crosses with spur-type Golden Delicious, also showed a tendency to transmit spurriness based on observations of 1-yr-old seedlings.

Single Preharvest Spray to Control Apple Breakdown

A single spray of 2.5 or 5% CaCl_2 with or without 20 ppm indolebutyric acid (IBA), or 20 ppm IBA alone applied 2.5 wk before harvest, reduced breakdown in Spartan apples. An analysis of calcium levels in the peel, flesh, and core of apples sprayed in 1972, 1973, or both years showed that the calcium sprays in 1972 did not raise calcium levels or control breakdown in apples harvested in 1973.

Maturity in Strains of Delicious Apples

Measurement of respiration rate and ethylene production showed no significant differences in maturity among the many Delicious strains studied: Gardiner, Starkrimson, Wellspur, Redspur, Hardispur, Harrold Red, Hi-Early, and Starking. Firmness, acidity, and flesh color were not consistently different at harvest or after 7 mo of storage.

Effect of Thinning and Gibberellic Acid on Grapes

A spray of gibberellic acid (GA) applied 10 days after full bloom increased berry size and yield of de Chaunac grapes. Berry set was not increased by GA and there were no significant interactions between the GA and thinning treatments.

Thinning to one basal cluster per bud reduced yield 25 to 30%, whereas thinning to two basal clusters did not reduce yield. Removal of the bottom one-quarter plus the late-blooming side arm from each cluster did not reduce cluster weight. Soluble solids

levels were substantially increased by all thinning treatments.

Grape Variety Evaluation

The breeding program at Summerland has produced at least five selections that offer promise for the production of Burgundy wines. The selections are 63 (Cascade \times Campbell Early), 88 (Erie \times N.Y. 33873), 149 (Golden Muscat \times Foch), and 239 and 245 (Kendaia \times Foch). These all appear to be sufficiently hardy, productive, and early to show promise for growers as well as wineries.

Peach and Nectarine Variety Evaluation

Peaches. Springold and Royal Gold (July 15–17) are now the early peaches recommended for local sales. Pats Early Redhaven (July 26) coincided with Early Redhaven and continued to be superior in quality and less inclined to have split stones. Urbin (July 31), a strain of Redhaven, appears to be considerably superior to the latter. Harken (Aug. 8) continues to be small and may be discontinued in favor of Harbrite. Merrill 49er (Sept. 12) continues to offer promise for late canning.

Use of *P. tomentosa* Seedlings for Stone Fruit Rootstocks

The dominant characteristic of six peach cultivars on rootstocks of *Prunus tomentosa* Thunb. has been lack of uniformity in growth, yield, and degree of suckering. By the 8th yr, some trees have died and about 30% are too small (2 m high) and lack vigor. The remainder vary from an ideal height of 3 m to nearly standard size. Yields also are variable, with the strongest trees not always the most productive. Rootstock selections are being made based on tree efficiency. *P. tomentosa* appears to be more suited to some plums and prunes than to peaches; cropping is more consistent, and size control is about right for plantings spaced at 2×3.5 m.

SOIL SCIENCE

Penetration of Calcium into Dipped Apples

Calcium continued to penetrate toward the core of Spartan apples for many weeks after a postharvest dip of the fruits in 4% CaCl_2 . Calcium contents of fruit disks excised at various depths from skin to core of the

apples increased steadily with time for 32 wk of sampling. After 32 wk, calcium contents at all depths were above the minimum regarded as the likely threshold for Spartan breakdown. Before 32 wk, portions of the fruit tissue midway between the skin and core were below that threshold.

Trickle Irrigation for Tree Fruits

Growth and production of tree fruits continued to be satisfactory with trickle irrigation, provided that the equipment performed according to design specifications. However, in the larger orchard installations, an estimated 500 man-hours of labor on 10 ha were required to clear or replace plugged microtube emitters. This number of man-hours compares favorably with the 600 man-hours and more required to move pipe for the sprinkler systems used on the same orchards before the trickle systems were installed. The labor for the trickle systems

was concentrated into short periods in June, July, and August, whereas that for the sprinkler systems was distributed evenly over 5 to 6 mo.

Trickle Irrigation on Grapes

Although the continuous trickle method of irrigation is satisfactory for grape production, it has shown no particular advantage over the sprinkler method in supplying water to the vines. Average yields of the grape cultivar Diamond were remarkably uniform at 6.5, 6.6, and 6.4 kg/vine in 1972, 1973, and 1974. These yields fell slightly short of the best ones associated with the highest frequency of sprinkler irrigation, but were well above the worst yields associated with the lowest frequency of sprinkler irrigation for the 5 yr before 1972. Plot-to-plot variability increased slightly each year from 1972, but there was no indication of a carryover effect of differential irrigation or cover crop treatments during the previous 5 yr (1967-72).

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INTRODUCTION

This is the 12th report from the Research Station, Vancouver, which is the national center for research on plant viruses. Research on regional problems in plant pathology and entomology is also emphasized.

During the year national meetings of both the American and Canadian Phytopathological Societies were held in Vancouver. Our staff was greatly involved in the planning, arranging, and running of these meetings. Their involvement was successful, judging from the letters of appreciation that were received by Dr. R. Stace-Smith, who was Chairman of the Local Arrangements Committee. The meetings, attended by almost 1200 people, were smoothly run, and few problems were encountered. Besides the responsibility of the physical arrangements for the meetings, our staff also participated greatly by presenting papers, as members of symposia, and in committee meetings.

The Pedology Unit, formerly a part of our staff, is now listed with the Soil Research Institute, Ottawa, even though it is still housed in our building.

Requests for details of our research program or for reprints should be made to individual scientists or addressed to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Physical and chemical properties of viruses in vitro. Purified preparations of a strain of carnation ringspot virus (CRSV) contained aggregates consisting of 12 virus particles arranged in icosahedral symmetry. Dimers of these aggregates containing 23 virus particles and polymers up to pentamers were also found. The sedimentation coefficients of the virus and of four classes of polymers were 135, 640, 932, 1175, and 1266 S. Purified preparations of another strain of CRSV contained aggregates in the form of two-dimensional sheets of virus particles. Reversible formation and dissociation occurred at 25° and 4°C respectively, which suggests that hydrophobic bonds may be involved in the aggregate formation.

Trypsin on brome mosaic virus at pH 8.0 released about 25 amino acid residues. Separation of the peptides on cation exchange resins and Sephadex G15 and determination of their N-terminus gave seven major peptides. These and eight "bridging" peptides containing more than one strongly basic amino acid (lysine and arginine) were assessed to propose a partial sequence. Arginine is very similar to the sequence of the first 25 residues in the amino terminus of cowpea chlorotic mottle virus protein. The function of this conservative region in the

protein of the two viruses is probably the binding site of the viral RNA.

Alfalfa mosaic virus (AMV) and turnip crinkle virus (TCV) were purified and their protein constituents prepared. Electrophoretic mobility measurements at pH 8.6 showed that AMV and TCV had a greater negative charge per unit surface area than did their respective proteins. Antibodies induced by the injection of AMV or the protein of TCV reacted with the viruses and their respective protein subunits in gel diffusion tests. The ratios of virus-reactive antibodies to protein-reactive antibodies were different in two fractions obtained by chromatography of the sera on DEAE-Sephadex. The first, more basic, DEAE-Sephadex fraction contained a greater proportion of virus-reactive antibodies than did the second fraction on the unfractionated antiserum.

Virus infection. Naturally occurring inhibitors of virus establishment appear particularly widespread among species of Engler's order Centrospermae. Two more genera of this order, *Montia* and *Saponaria*, were found to contain such active compounds. The inhibitor from *Saponaria officinalis* was very similar to a proteinaceous inhibitor from carnation described in previous reports in molecular size, chemical composition, and electrical net charge.

Naturally occurring compounds of low molecular weight interacting with viruses in vitro (virus inactivators) were detected in sundew, *Drosera rotundifolia* L. This plant contains two pigments whose molecular structure is based on a 1,4-naphthoquinone skeleton. We found that the commercially available compound 2-hydroxy-1,4-naphthoquinone (= lawsone) readily inactivated viruses in vitro, particularly potato virus X. Therefore, it is considered likely that the low molecular virus inactivators in *Drosera* are in fact the 1,4-naphthoquinone-based pigments.

The nature of the electron transparent areas in the outer cell wall of leaves was investigated by differential enzymatic, chemical, and staining techniques. These areas possibly constitute the ultrastructural equivalent of the light-microscopically-defined ectodesmata. They remained unchanged when ultrathin glycomethacrylate-embedded sections were exposed to cellulose at 37°C for up to 2 h at pH values of 4.5 or 6.3, and after prolonged exposure to ruthenium red. The treatment with ruthenium red clearly marked the middle lamellae of interior cell walls. Sections embedded in Epon were treated with boiling water or with solutions of various degrees of alkalinity at room temperature. These treatments were designed to solubilize pectins and hemicellulose materials from the cell walls, but they did not affect the electron transparency of the structures.

Virus transmission by seed. Inactivation of virus infectivity in maturing seed coats has been reported for a number of viruses, but little information is available regarding other properties of the viruses present in seeds. When clarified extracts of seed coats from bean, *Phaseolus vulgaris* L., were subjected to analytical density gradient centrifugation, those infected with southern bean mosaic virus (SBMV) contained three sedimenting components that were not present in comparable extracts from healthy plants. In extracts from immature seed coats the SBMV monomer and a slightly faster sedimenting component were observed; in extracts from mature seed coats only the faster sedimenting component was observed. In the transition from immature to mature seed coats, or after dehydration and rehydration of immature seed coats, there was a decline in the amount of SBMV monomer, an increase in the level of the faster sedimenting component, a transitory appearance of a third and fastest

sedimenting component, and finally the disappearance of the latter and of the SBMV monomer. The fast-moving components did not appear to be simple polymers of SBMV.

A seed-transmissible virus, isolated from seedlings of cowpea produced in Ghana, was identified as a strain of SBMV, on the basis of its antigenic, biological, and physical properties. The virus infected both cowpea (*Vigna unguiculata* (L.) Walp.) and bean systemically, but no systemic symptoms developed in bean. From sucrose gradient electrophoresis, mobilities of -3.3×10^{-5} and -3.7×10^{-5} cm² V⁻¹ sec⁻¹ were calculated at pH 7.0 for this strain of the virus and for SBMV respectively.

Particles resembling those of tobacco ringspot virus (TRSV) were detected by electron microscopy in ultrathin sections of ovules and pollen grains of soybean (*Glycine max* cv. Harosoy). The particles were present in the integument, nucellus, embryo sac wall, and megagametophytic cells of the ovules and in the intine, as well as in the wall and cytoplasm of the generative cells of the pollen.

Anthers of soybean infected with TRSV produced less pollen than anthers from virus-free plants; the pollen from infected plants was low in germination capacity and its germ tubes elongated more slowly than those from virus-free plants. Evidence from cross-pollination experiments suggests that infection of megagametophytes is the principal factor contributing to seed transmission of TRSV in soybean.

Aster yellows disease. Ultrathin sections of carrot root explants infected with aster yellows showed extensive invasion of the phloem area by mycoplasma-like bodies (MLB's). MLB's were equally distributed on both sides of the sieve plates. Most of the sieve pores in infected tissue cultures appeared to be open, and the apparent plugging sometimes seen was due to fixation artifacts as well as to MLB's. As pleomorphic structures, MLB's translocated with or without distorting their shape, according to their size and the degree of plugging of the sieve pores. Small particles, up to 200 nm in diam, changed their shape to pass through the sieve pore. Three phases were postulated to explain the translocation of large MLB's.

PLANT PATHOLOGY

Potatoes

Virus-free program. The use of heat therapy and axillary bud (meristem tip) culture since 1966 has enabled the eradication of potato virus X (PVX) or potato virus S (PVS), or both, from 143 clones of potato cultivars and seedlings. Fifteen of these clones were treated in 1974. Of the 128 clones treated in previous years, 55 clones of 36 licensed varieties and 49 clones of nonlicensed varieties and seedlings were grown in isolation plots. Seed stock was sent on request to Elite seed farms and research institutions in five provinces of Canada and to the USA and Australia.

Tests for PVX and PVS were conducted on leaf samples collected in the Pemberton and Cariboo control areas for seed potatoes. Samples were taken from 30 Elite 1 and 26 Elite 2 plots and from 121.7 ha (300.5 ac) of Elite 3 or Foundation seed. No infection was found in Elite 1 plots and no more than a trace of either virus was found in Elite 2 plots. Of the Elite 3 and Foundation seed plots, 83.8% contained 0–2.0% PVX and 89.6% contained 0–2.0% PVS ($P = 0.05$).

A diagnostic test for potato spindle tuber viroid was developed. The viroid could be distinguished from other lithium-chloride-soluble nucleic acids after electrophoresis on 5–8% polyacrylamide gels and staining with toluidine blue 0 in water. The terminal growth of infected stems contained a higher concentration of viroid than did the mature leaves or tubers. The method detected infection by mild and severe strains, but it did not distinguish between them.

Virology

Virus identifications. A virus infection of trailing black raspberry that occurs commonly in coastal British Columbia, including nonagricultural areas, was identified as a strain of tobacco streak virus. An apparently undescribed virus was isolated from cat's-ear, *Hypochaeris radicata* L. The virus has two classes of rigid rods, about 160 nm × 22 and 300 nm × 22.

Small Fruits

Blueberry and cranberry. Effective control of mummy berry, caused by *Monilinia vaccinii-corymbosi* (Reade) Honey, of highbush

blueberry by triforine (Cela W524; Celamerck GBMH and Co.) at 0.28 kg (ai)/ha, or triforine at 0.28 kg plus benomyl at 0.56 kg/ha was achieved again in 1974. In fungicide trials with cotton ball of cranberry, caused by *Monilinia oxycocci* (Wor.) Honey, triforine significantly reduced ascospore infections. Registration of triforine for use on these two crops is recommended.

Strawberry and raspberry breeding. Because of its fruit quality, winterhardiness, and virus tolerance, the strawberry cv. Totem has become the major cultivar in British Columbia and is being used extensively in the strawberry breeding program. The most promising crosses observed in 1974 were Totem × Tioga, Bounty × Totem, and Kentville 69-108 × Totem. In the raspberry breeding program the emphasis was placed on immunity from the aphid *Amphorophora agathonica* Hottes and low susceptibility to spur blight, *Didymella applanata* (Niessl) Sacc., and to fruit rots. The two most promising seedlings in 1974 were 65-2-16 (Creston × SHRI 6010/52) and 64-9-81 (Creston × Willamette). Both will be tested widely.

Nematodes

The effect of DBCP (Nemagon; Shell Canada Ltd.) on numbers of nematodes and growth and yield of plants is being studied in established raspberry plantings. Applications by chisel injection into the soil and through a trickle irrigation system will be made on three schedules: once only, every 2 yr, and every 3 yr. Studies continued on the effect of the systemic nematocide oxamyl (Vydate; DuPont of Canada Ltd.) on established raspberries. Nematode population, cane heights, and numbers of new canes were recorded.

ENTOMOLOGY

Vectors

Microorganism-like bodies. Examination by electron microscopy of the salivary glands and the saliva of the aster leafhopper, *Macrostelus fascifrons* (Stål), revealed three kinds of membrane-limited microbodies. Typical mycoplasma-like bodies (MLB's) were found in the salivary glands of leafhoppers transmitting aster yellows, but not in those never exposed to a disease source.

Rickettsia-like bodies (RLB's) and microbodies, probably associated with the secretion of saliva, were found in both transmitting and nontransmitting leafhoppers. Pronase digested the salivary microbodies in 20 min and pepsin after 2 h, but neither enzyme had any effect on MLB's or RLB's.

Morphology and fine structure. Aphid species examined in our study comparing the mouthparts of aphids were: *Acyrtosiphon dirhodum* (Walker), *Aphis nasturtii* Kalt., *Drepanosiphum platanoides* (Schränk), *Euceraphis punctipennis* Zett., *Masonaphis maxima* (Mason), *Myzocallis coryli* (Goeze), *Pemphigus spirothecae* Pass., *Periphyllus testudinaceae* (Ferne), *Pterocomma* sp., and *Rhopalosiphum padi* (L.). Morphs not previously examined include the fundatrices of *Acyrtosiphon pisum* (Harris), *M. maxima*, *E. punctipennis*, *P. spirothecae*, and *P. testudinaceae* and the sexuales of *E. punctipennis*, *D. platanoides*, *M. maxima*, *P. spirothecae*, and *P. testudinaceae*. All the specimens examined, except the sexuals of *P. spirothecae*, had their mandibular stylets innervated by two dendrites contained in a central canal. The sexuals of *P. spirothecae* apparently lack stylets and the labium is rudimentary. The stylets of 23 species of aphids, including most of the important genera, have been studied.

Aphid species. Forty-eight species were added to the taxonomic list of aphids that occur in British Columbia. Thirty-nine species of plant hosts and 128 new aphid – plant host associations were included in the publication. The additions bring the number of known aphid species in the province to 261. The life cycle of a gall aphid, *Pemphigus spirothecae* Pass., on lombardy poplar was studied.

Aphid ecology. After 3 yr of work, a realistic, experimentally developed, computer simulation model was completed, which shows the changes in numbers of pea aphids, *Acyrtosiphon pisum* (Harris), on alfalfa in the field caused by predation by lady beetles, *Coccinella* spp. The results contradict accepted theories and opinions on predator-prey relationships. The usual ecological assumption of a steady state of balance did not exist. The relationship studied was unstable, and the beetles were not able to keep the aphid numbers low for any protracted period. Usually the beetles only slowed the rate

of increase in population. The predation rate depended upon temperature, age distribution of the prey, dispersion of the aphids between plants, rainfall, and sunshine. The beetles flew away as soon as they had reduced the aphid numbers, leaving a few aphids to increase unimpeded. By their effect on vector aphids, it may be that lady beetles increase the spread of virus within a field.

Strawberry Pests

Root weevils. After the third cropping season of barriered microplots, each enclosing five cultivars and one of four species of nonflying weevils at low or high levels, the experiment was ended. The barriers were effective in excluding adult weevils but less so in confining them. Damage in all the plots was severe, but it was more severe in plots with initial infestations of 50 adults than in those with 200. These results were obtained with all of the pest weevils: *Otiorhynchus sulcatus* (F.), *O. ovatus* L., *Sciopithes obscurus* Horn, and *Nemocestes incomptus* (Horn). The cv. Cheam was the least affected, Totem and Shuksan were affected somewhat more, and Northwest and BC-25 sustained the most damage.

Strawberry tortrix. *Acleris comariana* (Zeller) is a recently introduced European pest. The effectiveness of carbofuran for control of its larvae was confirmed. Other effective compounds were diazinon, methomyl, and methidathion. There were no reports of the pest from outside the original area of infestation. The polyembryonic parasite, *Copidosoma* sp., was unusually abundant.

Raspberry Pests

Root weevils. Adult black vine weevils, *O. sulcatus* (F.), were kept individually on the foliage of eight cultivars. Measurements of five parameters taken together indicated that the susceptibility of the cultivars, from least to most, was Glen Clova, Malling Jewel, Comet, Meeker, Willamette, Haida, Newburgh, and Southland.

Wireworms

Chemical control. Five insecticides were tested in fields of potatoes and maize for control of European wireworms, *Agriotes obscurus* L., at 75/m². The insecticides were applied in a band, in a furrow, or broadcast. Untreated plots yielded 42% undamaged

potato tubers, and the most effective treatments 75%. The currently recommended fonofos, applied as granules in a band at 2 kg/ha (or one-third of the broadcast rate), yielded 70% undamaged tubers. This method is worth further study.

In maize, fonofos broadcast produced a yield of 44 kg/10 m row, whereas untreated rows yielded 19 kg/10 m. Again, the band and furrow methods produced somewhat lower yields but used only one-third the amount of the insecticide. About 37% of the wireworms found after harvest had been recently hatched, which indicates that none of the chemicals had been effective for more than a few weeks.

Leatherjackets

Biological control. Populations of the European crane fly, *Tipula paludosa* Meigen, in untreated grassland and in flight, declined further during 1974. The effect is ascribed in part to parasitism by *Nosema* protozoans and by gregarines of the genera *Diplocystis*, *Actinocephalus*, and *Hermicystes*. The parasitic tachinid fly, *Siphona geniculata* De Geer, became well established, and large numbers of adults were collected in the field for successful shipment to Newfoundland.

Weeds

Biological control. In continuing cooperation with the Research Station, Regina, a trypetid fly, *Urophora stylata* (Fabr.), which causes galls in the flower head of bull thistle, *Cirsium vulgare* (Savi) Tenore, was released and established in 1973. In 1974, it was recovered near each of the three release sites. From 30 to 45% of the heads examined contained galls. A related species, *U. cardui* (L.), which causes galls in the terminals and shoots of Canada thistle, *C. arvense* (L.) Scop., was released in 1974, but was not recovered.

The weed tansy ragwort, *Senecio jacobaea* L., continued to spread, but larvae of the cinnabar moth, *Tyria jacobaeae* (L.), were in reduced numbers generally. The flea beetle, *Longitarsus jacobaeae* Watr., whose larvae attack the roots, was released for the fourth season, but was not recovered.

Root Maggots

Compatibility and biological control. Five insecticides were applied to the soil at seeding, at one-half of the recommended

rate, in broccoli, Brussels sprouts, cabbage, and cauliflower. A preemergence spray of the herbicides niclofen and propachlor was applied 3 days later. Each plot was divided into three subplots, one unsprayed, the others sprayed with methomyl or *Bacillus thuringiensis* (Berliner) at 25×10^9 viable spores/g (Dipel). Pit traps were set in open areas and in areas enclosed by plastic barriers to determine the species of carabid beetles, their susceptibility to the pesticides, and changes in their numbers with time.

The soil insecticides were significantly effective, and none reduced emergence of the seedlings. Methomyl sprays kept populations of the aphids *Myzus persicae* (Sulz.) and *Brevicoryne brassicae* (L.) to low levels. Pit traps in open areas caught more beetles than those in enclosed areas. From the open areas, 1996 beetles were collected from grass; 2914 from crops; and 3514 from cultivated soil. The most common predators on the eggs of *Hylemya brassicae* (Bouché) were *Calathus fuscipes* (Goeze), 4740 trapped; *Bembidion lampros* (Hbst.), 2304; *Harpalus affinis* Schrk., 920; and *Pterostichus melanarius* Ill., 939. Few parasitic staphylinid beetles were trapped, for example, only 16 *Aleochara bilineata* Gyll., but later studies indicated that parasitism in the pupae of the cabbage fly was greater than 25%. Toxicological studies showed that one of the insecticides, the phosphorothioate AC 92100 (Cyanamid of Canada Ltd.), is extremely harmful to *A. bilineata* and *B. lampros*.

Potato Pests

Flea beetles and aphids. Six insecticides in granular form were applied in bands before planting potatoes. Three supplementary sprays of other compounds were applied to plots treated with three of the granular insecticides and to three plots that had not been treated, at 2-wk intervals from mid-July. The effects were measured by weekly counts of aphids, the feeding holes of the beetles, and their larvae in leaves and tubers.

Aphids increased regularly except in plots sprayed with amidophos, which reduced a population of 355 to 8 during the 8-wk sampling period. Amidophos also effectively reduced the damage by beetles to the leaves. There were 38% unmarketable tubers in the untreated plots but none in the plots treated with granular carbofuran. The yield of marketable tubers was 13,600 kg/ha from

untreated plots and 26,600 kg/ha from those treated with granular fensulfothion.

Residue Chemistry

Organophosphorus residues. Methods recently developed at the Station for determining residues of phorate and its five metabolites were used in the analysis of field-treated carrots; the distribution and degradation of the pesticide were determined. The distribution of residues was similar to that of carbofuran and ethion: the greatest concentration occurred in the top 3 cm, and the peel had residues about an order of magnitude higher than the corresponding pulp. Small amounts of phorate were found in its original

form, most of it having degraded to the sulfone and especially to the sulfoxide.

Carbamate residues. The uptake and movement of carbofuran applied to the soil of vineyards were followed in the leaves, grapes, wines, and soil. The usual method was modified in order to obtain acceptable recoveries and freedom from interference, especially in the wines, in which the presence of ethanol required additional steps. Carbofuran was also sprayed on the leaves and bases of raspberry plants. After 3 wk, fruit from the basally-treated plants contained less than one-quarter of the amount of carbofuran found in fruit from the foliar-treated plants. After 4 wk, residues in the former had decreased to one-tenth of those in the latter.

PUBLICATIONS

Research

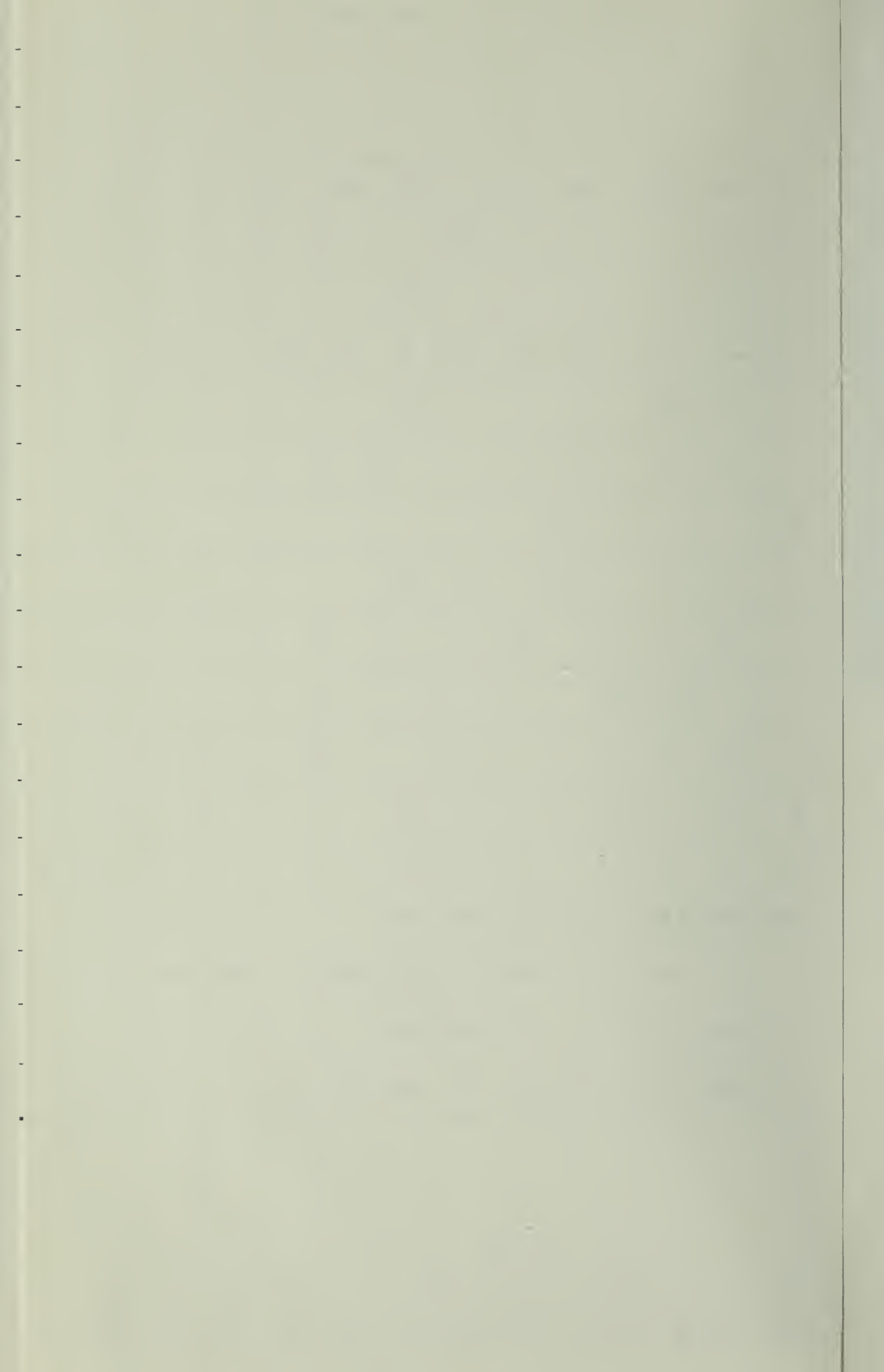
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PROGRAM STRUCTURE			
RESEARCH BRANCH CANADA AGRICULTURE			
AIM	OBJECTIVES	GOALS	July, 1974
FORAGE CROPS	1 To improve the efficiency of production and the quality of forage crops	1 By 1976 to have raised the unit yield of digestible dry matter of legume crops by 10%, through the development of improved management practices, superior varieties, and increased seed production	2 By 1975, to have raised the unit yield of digestible dry matter of grass crops by 10%, through the development of improved management practices, superior varieties, and increased seed production
	Man Years 70.7		
OILSEED CROPS	2 To improve the efficiency of production, adaptability and quality of oilseed crops and their products	1 By 1976 to have increased the unit yield of rapeseed and mustard by 5%, and to have increased the unit yield of sunflower seeds by 10%, through the development of improved varieties and better management practices	2 By 1977, to have increased the unit yield of small fruits by 10%, while maintaining higher standards of fresh and processed quality through the development of improved cultivars and management practices
	Man Years 38.0		
HORTICULTURAL CROPS	3 To improve the efficiency of production and the quality of horticultural crops	1 By 1976 to have increased the unit yield of tree fruits by 10%, while maintaining standards for fruit quality and yield, through the development of improved varieties and better management practices	2 By 1977, to have increased the unit yield of small fruits by 10%, while maintaining higher standards of fresh and processed quality through the development of improved cultivars and management practices
	Man Years 38.0		
CEREAL CROPS	4 To increase the efficiency of production and the quality of cereal crops	1 By 1976 to have increased the unit yield of durum, winter, and spring wheats by 5%, while maintaining the quality of each crop to meet market demands, through the development of improved varieties and management practices	2 By 1976 to have increased the unit yield of barley by 10%, while maintaining the quality to meet market demands, through the development of superior varieties and improved management practices
	Man Years 168.0		
FIELD CROPS	5 To improve the efficiency of production and the quality of field crops such as tobacco, bushbean, field peas, beans, new crops, and sugar beets	1 By 1976 to have increased the unit yield of tobacco by 10%, while maintaining quality standards to meet market demands, through the development of superior varieties and improved management practices	2 By 1977, to have increased the unit yield of bushbean by 10%, while maintaining quality to meet market demands, through the development of superior varieties, and improved management practices
	Man Years 134.6		
INSECTS	6 To develop and improve methods for the production of crop plants from insects and related pests	1 By 1976 to have defined new physiological and biochemical target sites for mode of action and basis for insecticide resistance	2 By 1976 to have defined new physiological and biochemical target sites for mode of action and basis for insecticide resistance
	Man Years 37.1		
PLANT DISEASES	7 To maintain or increase productivity and quality through reduction of losses from plant diseases	1 By 1976 to have developed a better understanding of tobacco quality and to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 33.4		
WEEDS	8 To develop and improve methods for the control of weeds	1 By 1976 to have developed a better understanding of tobacco quality and to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 18.4		
PLANT ENVIRONMENT	9 To explore and exploit the effects of environmental factors on plant growth and development	1 By 1976 to have developed a better understanding of tobacco quality and to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 17.9		
SOIL MANAGEMENT	10 To develop improved soil and water management practices	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 18.7		
SOIL SURVEY	11 To obtain a reliable inventory of Canadian soil resources (nature extent and distribution pattern of soil environments) and to interpret the capabilities and limitations of soil resources for agriculture and other uses	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 41.8		
BIOSYSTEMATICS	12 To improve our understanding of the taxonomic relationship of plants, insects, and micro-organisms	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 37.7		
DAIRY CATTLE	13 To improve the efficiency of production and the quality of dairy products	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 24.5		
BEEF CATTLE	14 To improve the efficiency of production and quality of beef products	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 38.4		
SHEEP	15 To improve the efficiency of production and the quality of products from sheep	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 7.1		
SWINE	16 To improve the efficiency of swine production and the quality of pork and pork products	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 11.7		
POULTRY	17 To improve the efficiency of production and the quality of products from poultry	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 18.2		
OTHER ANIMALS AND FOREST TREES	18 To improve the efficiency of production of other animals and forest products	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 3.3		
ANIMAL PHYSIOLOGY	19 To elucidate selected physiological functions of animals including reproductive, metabolic, and growth processes	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 7.7		
ENVIRONMENTAL QUALITY	20 To identify, measure and establish significance of pollutants affecting the utilization or quality of soil, plants, animals, food, air and water	1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 22.5		
SERVICE GOALS		1 By 1976 to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices	2 By 1977, to have increased the unit yield of tobacco by 10%, through the development of improved varieties and management practices
	Man Years 7.0		

DEPARTMENTAL AIM
To develop a viable and self-sustaining agricultural industry based on bee trade and self-sustaining practices.

- 4 By 1976, to have increased the unit yield of potatoes by 5%, while achieving higher standards of fresh and processed quality, through the development of improved cultivars and better management practices.
- 5 By 1977, to have developed 10 new cultivars of selected *ornamentals*, and to have increased floriculture productivity by 5% while maintaining present quality of greenhouse flowers, outdoor plantings, and nurseries.



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MAR 19 2010			
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